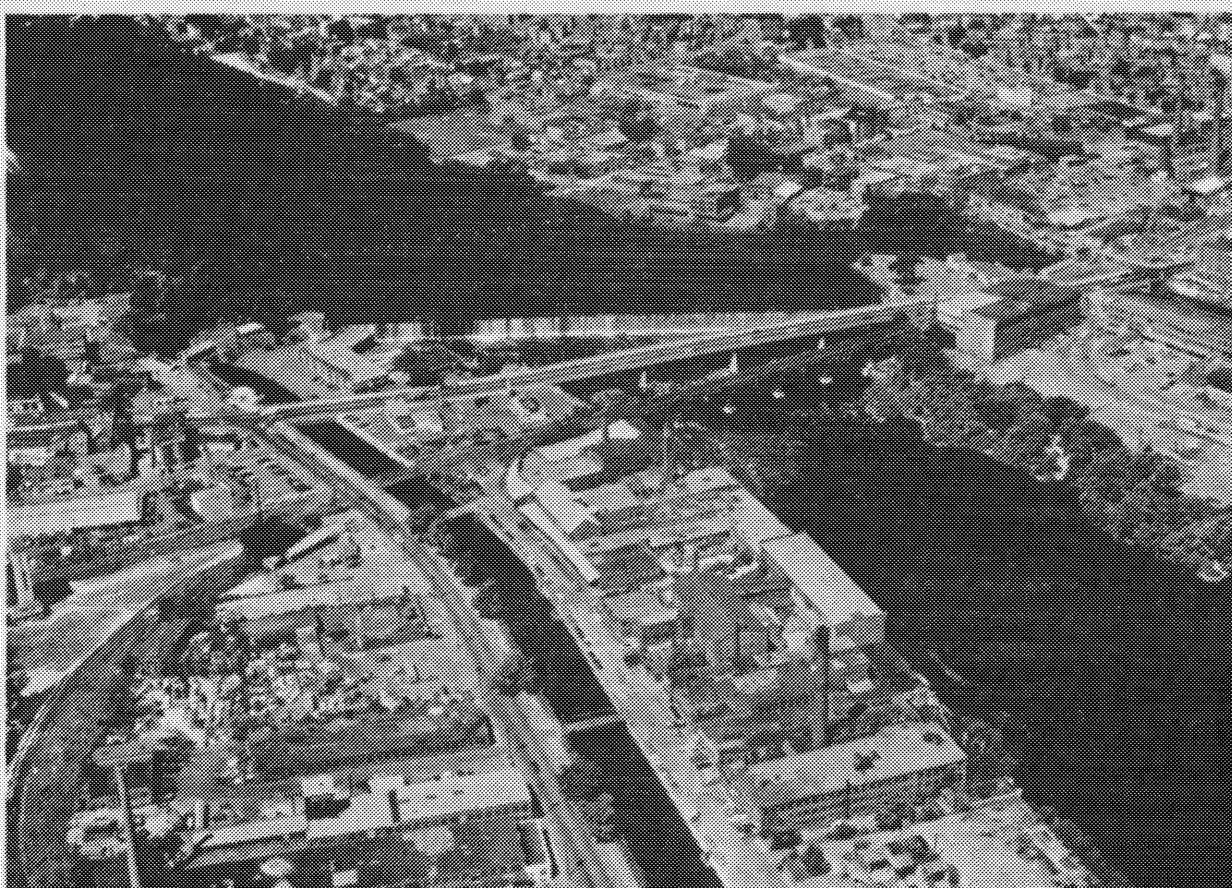
FLOOD PLAIN INFORMATION

MERRIMACK — SHAWSHEEN — SPICKET RIVERS

LAWRENCE, METHUEN, ANDOVER & NORTH ANDOVER, MASSACHUSETTS



PREPARED FOR LAWRENCE, METHUEN, ANDOVER & NORTH ANDOVER, MASSACHUSETTS BY THE DEPT. OF THE ARMY, NEW ENGLAND DIV., CORPS OF ENGINEERS, WALTHAM, MASS.

MARCH 1972

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INTRODUCTION

This report relates to the flood situation along the Merrimack River, the Shawsheen River, and the Spicket River in the vicinity of Andover, Lawrence, Methuen, and North Andover, Massachusetts. It was prepared at the request of the Central Merrimack Valley Regional Planning District Commission comprised of Andover, Lawrence, Methuen, and North Andover to aid in the solution of local flood problems and in the best utilization of land subject to overflow. The report is based upon information on rainfall, runoff, historical and recent flood heights, and other technical data bearing upon the occurrence and size of floods in the Central Merrimack Valley Regional Planning District.

The report covers two significant phases of the District flood problems. It first brings together a record of the largest known floods of the past on the Merrimack River, the Shawsheen River, and the Spicket River. Secondly, it discusses the probability of future floods of various magnitudes including the Intermediate Regional Flood and Standard Project Flood. Intermediate Regional Floods are floods that have an average frequency of occurrence in the order of once in 100 years and are determined from an analysis of known floods on the Merrimack and the two tributaries under study, and other streams which have similar physical characteristics and are in the same geographical region. Standard Project Floods are floods of rare occurrence and, on most streams, are considerably larger than any floods that have occurred in the past. However, they should be considered in planning for use of the flood plains.

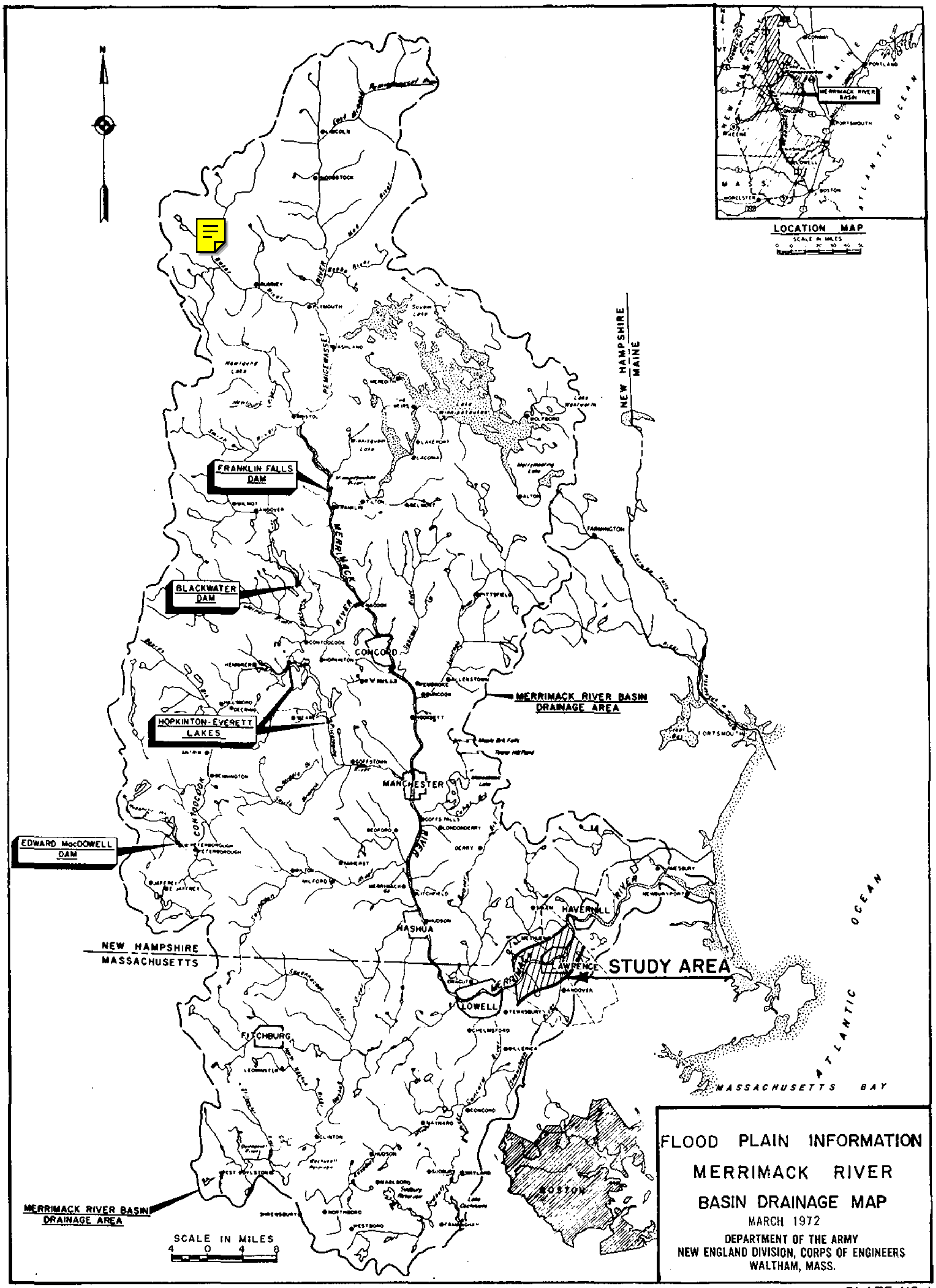
In problems concerned with the control of developments in the flood plains of the Merrimack, Shawsheen and Spicket Rivers and in reaching decisions on the size of floods to consider for this purpose, appropriate consideration should be given to the possible future occurrences of floods of the size of those that have occurred in the past, the Intermediate Regional Floods and the Standard Project Floods.

The report contains maps and profiles which indicate the extent of flooding which might occur in the future in the vicinity of the four municipalities. This should prove useful in planning the best use of the flood plains. From the maps and profiles, the depth of probable flooding by occurrence of the Intermediate Regional or Standard Project Floods at any location may be learned. With this information, floor levels for buildings may be planned high enough to avoid flood damage or, if at lower elevations, with recognition being taken of the chance and hazards of flooding.

The report does not include plans for the solution of flood problems. Rather, it is intended to provide the basis for additional investigation and planning by the four communities so that they may arrive at equitable and compatible means to reduce flood damages. This might involve local planning programs to guide developments by controlling the type of use made of the flood plain through zoning and subdivision regulations, the construction of flood protection works, or a combination of the two approaches.

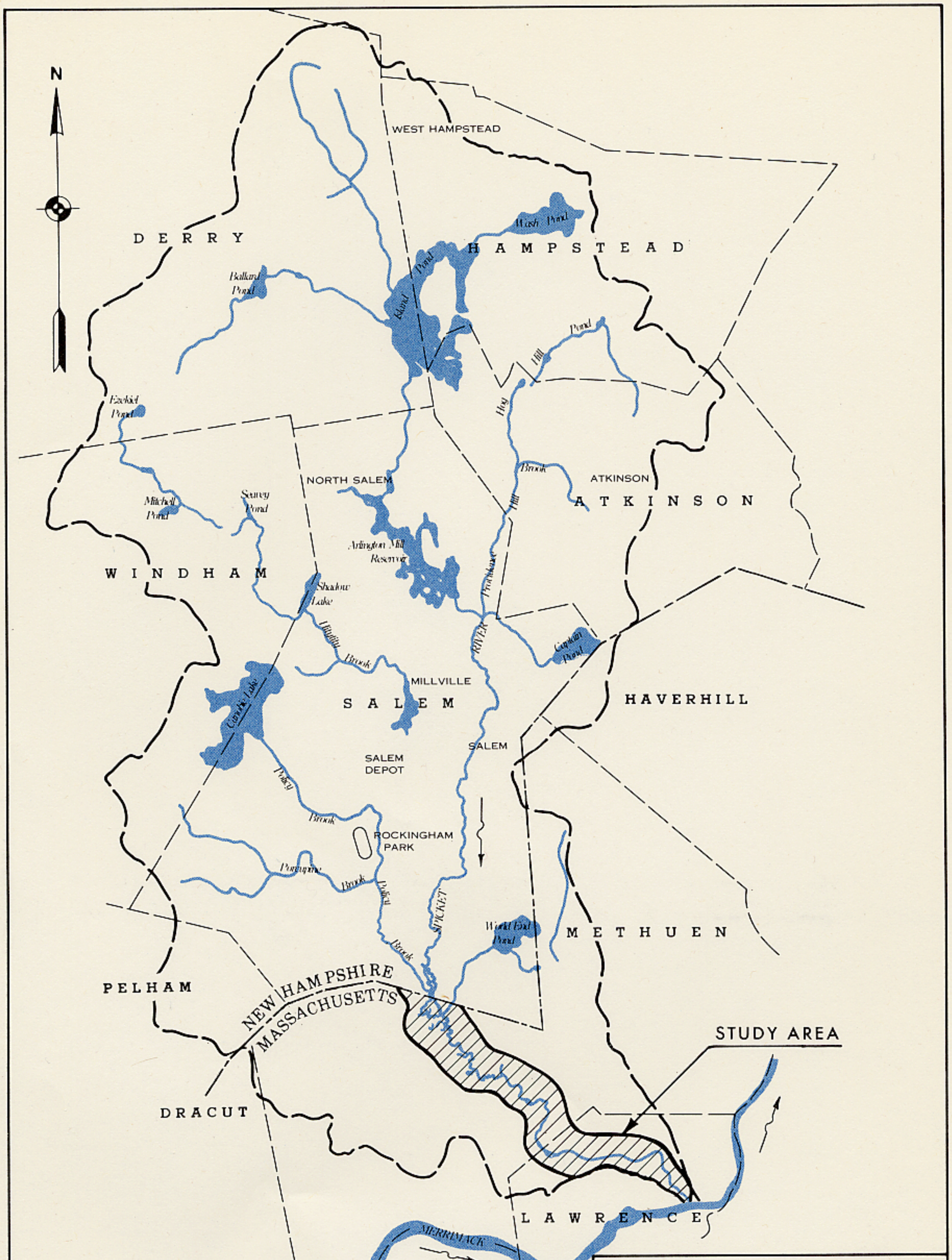
It is not intended to extend any Federal authority over zoning or other regulation of flood plain use, and the report is not to be construed as committing the Federal Government in the future to investigate, plan, design, construct, operate or maintain any facilities discussed, or to imply any intent to undertake such activities unless specifically authorized by the Congress. It is intended, as mentioned before, as an aid to local authorities.

The New England Division of the Corps of Engineers will, upon request, provide technical assistance to Federal, State, and local agencies in the interpretation and use of the information contained herein and will provide other available flood data related thereto.



FLOOD PLAIN INFORMATION
MERRIMACK RIVER
BASIN DRAINAGE MAP
MARCH 1972
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. 1



FLOOD PLAIN INFORMATION

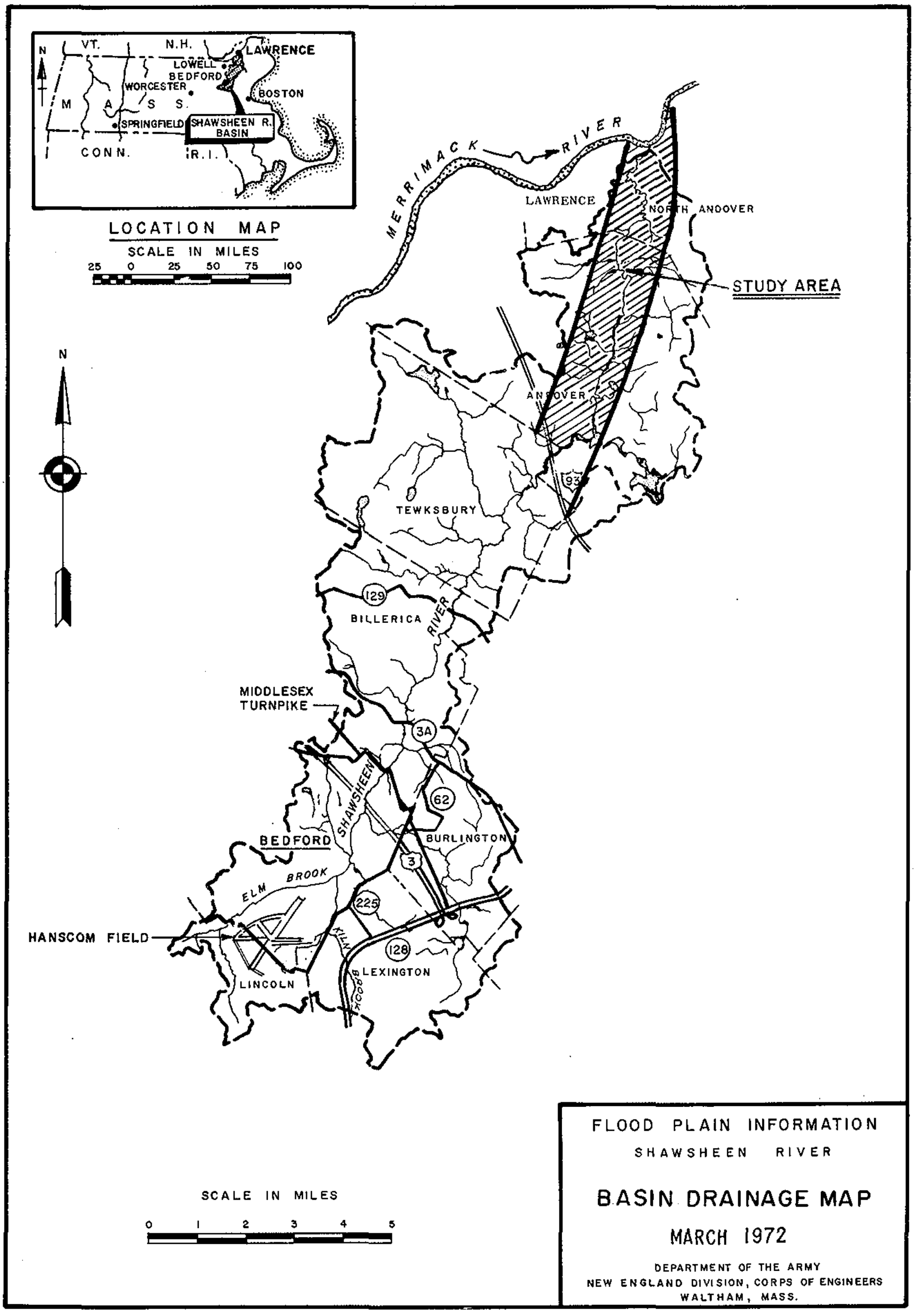
SPICKET RIVER

BASIN DRAINAGE MAP

MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO.2



FLOOD PLAIN INFORMATION

SHAWSHEEN RIVER

BASIN DRAINAGE MAP

MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

SUMMARY OF THE FLOOD SITUATION

The city of Lawrence and the towns of Andover, Methuen, and North Andover are located in northeastern Massachusetts on the Merrimack River. The city of Lawrence straddles the Merrimack River approximately in the center of the area occupied by the four communities. North of the Merrimack, the city is bounded on the west, north and east by the town of Methuen. South of the river the city is bounded on the west and south by the town of Andover and on the east by the town of North Andover. (see Plate 1) The Spicket River flows in a southeasterly direction from the New Hampshire boundary at the northwest corner of Methuen to the Lawrence city line thence centrally through Lawrence to the mouth of the river on the left bank of the Merrimack. (see Plate 2) The Shawsheen River flows in a northerly direction in the center of the easterly half of the town of Andover from the Tewksbury town line to the Lawrence city line, then through the south east corner of Lawrence for about a half mile to the North Andover town line where it becomes the boundary between Lawrence and North Andover for the remaining distance to the right bank of the Merrimack River, a distance of approximately two miles. (see Plate 3)

Most of the past development in the four communities has taken place on land above the flood plain. This is primarily due to a relatively narrow flood plain in the upper reach of the Shawsheen River and the lower reach of the Spicket River in the study areas. On the Merrimack River, the flood plain upstream from the Essex Company Dam is narrow with very little residential or commercial development in the flood plain.

The Essex Company of Lawrence, Massachusetts, maintains 3 gaging stations in the study area. One is located at the Essex Dam. Another is located on the right bank of the Merrimack at river Mile 28.4 and another on the left bank of the Merrimack at the Lower Locks. There is also a gage at the Malden Mills Dam on the Spicket River and one on the left bank of the Shawsheen River at the Loring Street-Massachusetts Avenue Bridge. Residents along the rivers have been interviewed and newspaper files and historical documents have been searched for information concerning past floods. From these investigations and from studies of possible floods on the Merrimack, Shawsheen and Spicket Rivers, the local flood situation, both past and future, has been developed. The following paragraphs summarize the significant findings which are discussed in more detail in succeeding sections of this report.

THE GREATEST FLOOD known to have occurred on the Merrimack, Shawsheen and Spicket Rivers at Lawrence during the past 100 years or more occurred in March 1936. Newspapers and records point out the disastrous proportions of this flood in the area studied and leave no doubt that it was far greater than any other flood.

* * *

ANOTHER GREAT FLOOD, which was the second highest flood on the Merrimack, Shawsheen and Spicket Rivers, occurred in September 1938. This flood was about 3 feet lower than the March 1936 flood at the Essex Company Dam in Lawrence.

* * *

OTHER LARGE FLOODS on the Merrimack, Shawsheen and Spicket Rivers occurred in April 1852, March 1896 and April 1870. These floods were within 4 to 5 feet of the March 1936 flood at the Essex Company Dam in Lawrence.

* * *

OTHER FLOODS that caused damage have occurred along the Merrimack River and its tributaries since the founding of the first settlements in the basin. According to available records, there was a flood in the lower valley in 1785 which was of about the magnitude of those of

1852, 1870, and 1896. Very little information is available on the magnitude of these earlier floods but it is reported that the flood of March 3, 1896 was caused by a maximum rainfall of 9.54 inches plus melting snow.

* * *

<u>INTERMEDIATE REGIONAL FLOODS</u> on the Merrimack, Shawsheen and Spicket Rivers are floods that have an average frequency of occurrence in the order of once in 100 years. They are determined from an analysis of floods on these streams and other streams in the same general area. The analysis indicates that the Intermediate Regional Flood for the Merrimack River in the reach studied, modified by 5 flood control dams upstream in the basin, would be about 10 feet lower than the March 1936 flood. The Intermediate Regional Flood for the Shawsheen River would be about 4 feet higher than the March 1936 flood except for a reach of approximately 4.5 miles from its confluence with the Merrimack River which is affected by backwater from the Merrimack. In this reach of the Shawsheen, the Intermediate Regional Flood would be about 10 feet below the March 1936 flood. The Intermediate Regional Flood on the Spicket River and the March 1936 flood are approximately identical, except at the mouth of the river where backwater from the Merrimack River, causes the IRF to be about 8 feet lower than the March 1936 flood.

* * *

STANDARD PROJECT FLOOD determinations, modified by 5 flood control dams upstream in the basin, indicate that floods could occur on the Merrimack River that would be about 3 feet below the March 1936 flood and about 7 feet above the Intermediate Regional Flood. Standard Project Floods on the Shawsheen River would be about 1 to 8 feet higher than the Intermediate Regional Flood and 1 to 3 feet lower than the March 1936 flood. On the Spicket River, the Standard Project Flood would be about 2 feet higher than both the Intermediate Regional Flood and the March 1936 flood. The Standard Project Flood is an estimated flood condition which is considered to be possible while extremely rare.

* * *

FLOOD DAMAGES that would result from recurrences of major known floods and from the Intermediate Regional and Standard Project Floods would be extensive because of the large area that would be inundated and the depth of the water. The increase in damages would be substantial due to developments in the flood plain and will increase unless continual restrictions are maintained.

* * *

MAIN FLOOD SEASON for the Merrimack, Shawsheen, and Spicket Rivers is in the spring. These floods are caused by warm rain augmented by melting snow. Although the basin is exposed to tropical storms of the fall season and to other types of storms at all times of the year, the occurrence of floods at any other time than in the spring is rare. Records show that eight of the ten greatest floods at Lawrence occurred in either March or April. The remaining two were in September and November.

* * *

FLOOD DAMAGE PREVENTION MEASURES There are no existing, authorized or proposed flood control or related measures in the study area or upstream in the watersheds for the Shawsheen and Spicket Rivers. There are, however, four flood control reservoirs on the Merrimack River watershed that control flood stages in the reach of the Merrimack River covered in this study. These reservoirs are listed later in the report.

* * *

FUTURE FLOOD HEIGHTS of the Intermediate Regional Flood, the September 1938 flood, and the Standard Project Flood related to the major flood which occurred in March 1936, are shown in Table 1. The table shows the comparison of the flood heights at the Essex Company Dam in Lawrence.

* * *

TABLE 1

RELATIVE FLOOD HEIGHTS

Flood	Relation to March 1936 Flood at Essex Co. Dam in feet
March 1936	0
September 1938	-3.1
Intermediate Regional	-5.8
Standard Project	-2.8

GENERAL CONDITIONS AND PAST FLOODS

General

This section of the report is a history of floods on the Merrimack, Shawsheen and Spicket Rivers in the study area of the four municipalities. The portion of the Merrimack River studied extends from the Dracut-Tewksbury-Andover townline to the Methuen-Haverhill townline. The study also includes the portion of the Spicket River from the Massachusetts-New Hampshire state line in Methuen to the Merrimack River in Lawrence and the portion of the Shawsheen River from the Merrimack River to the Andover-Tewksbury townline. The drainage area of the Shawsheen River is approximately 74 square miles and the Spicket River has a drainage area of approximately 74.5 square miles. The drainage area of the Merrimack River at the Essex Company Dam is 4,672 square miles.

From the Essex Company Dam to the mouth of the Shawsheen River in Lawrence, the area is well developed industrially and was flooded over a considerable area during the March 1936 flood. The area along the lower reach of the Shawsheen in Lawrence and North Andover is also well developed industrially and residentially. The lower reach of the Shawsheen is affected by backwater from the

Merrimack River to the old Stevens Dam (approximately 4 1/2 miles upstream) during flood stages on the Merrimack River. From the mouth of the Shawsheen River to the downstream limit of this study on the Merrimack River the flood plain on the right bank is narrow while the left bank flood plain varies in width from 100 feet to 1500 feet. Regulation of the flood control dams upstream will modify flooding of these areas.

The Corps of Engineers has been collecting information for many years on existing and prospective flood conditions and hazards in the vicinity of Lawrence, Massachusetts. Investigations were made following all of the floods that have occurred in the area since March 1936. The information, such as high-water marks, has been obtained by interviewing local residents and making field investigations. Office computations have been made to supplement this data and to develop the flood profiles. A search was also made of newspaper files and historical documents. From these sources, and gage records, it has been possible to develop a history of the floods on the Merrimack, Shawsheen and Spicket Rivers.

Settlement

Andover - Andover was originally settled about 1642 and was known as Cockicewick, an Indian name for a brook in the locality. In 1646, it was officially incorporated as a town and the name was changed to Andover after a town in England, the origin of many of its settlers. Manufacturing was encouraged early. The first powder mill in Massachusetts was established in 1775 by Samuel Phillips. Operations at the mill were discontinued after 20 years because of frequent explosions. Paper manufacturing was started in 1789 and this industry prospered until 1821. Manufacturing of woolen yarns was started in 1821 by Abraham Marland and the mills were sold in 1879 to M. T. Stevens. Mr. Stevens added these mills to others started as early as 1813 by Nathaniel Stevens. These mills have been managed by the Stevens family for many generations. Other products manufactured in Andover were products made from flax fibers by John Smith & Company in 1834; white flannel by Ballard Vale Manufacturing Company in 1836; rubber goods by the Tyer Rubber Company in 1856. Andover is noted for the educational institutions located within the town limits; Phillips Academy and the Abbot Academy. Phillips Academy was founded in 1770 by Samuel Phillips and its growth to fame has been aided by the Phillips family.

Abbot Academy was the first exclusive school for girls in this section of the country and was started in 1829 through the efforts and bequests of Sarah Abbot. Major new developments in Andover are a $4, 763, 500 Internal. Revenue building; a $650, 000 dormitory for Phillips Academy; a $3, 900, 000 high school; a $400, 000 research laboratory; a $1, 609, 000 elementary school; and a $3, 900, 000 plant for the Gillette Safety Razor Company. The town has a building code and a planning board which exercises subdivision control powers. A master plan has been completed and the town is a member of the Central Merrimack Valley Regional Planning District Commission.

Lawrence - The city of Lawrence was established April 17, 1847 and incorporated as a city March 21, 1853. In 1845, a group of Boston financiers formed the Essex Company for the purpose of utilizing the water power of Bodwells Falls in the Merrimack River. By 1848, the Essex Company had completed the dam, constructed two canals, erected a machine shop for the building of locomotives, a reservoir on Prospect Hill, gas works, fifty brick buildings, and a large boarding house and plants of the Atlantic Cotton, Pemberton, Upper Pacific and Dreck Mills. The city was built and populated almost overnight, but at the beginning, it was lacking many of the actual necessities of community life.

The first store was set up near the Andover Bridge by Amos Pillsbury in 1846. The Boston and Maine Railroad introduced passenger train service in 1847. The builders of this city made Lawrence one of the greatest textile centers in the nation. Some of the original mills remain in Lawrence today and the city continues to be of major importance as a textile center but has sought, in recent years, to diversify its economic base and attract industries manufacturing products other than textiles. Manufacturing is the predominant economic pursuit in Lawrence. The five leading types of manufacturers in the order of their importance in 1966 were: leather and leather products, textile mill products, electrical machinery, rubber products, and apparel and other finished goods. The city of Lawrence has a building code and a planning board, with a paid staff which exercises subdivision control powers. A master plan has been completed and the city is a member of the Central Merrimack Valley Regional Planning District Commission.

Methuen - Methuen was originally a part of Haverhill until its incorporation as a town in 1725. It was named after Lord Methuen, an English official of pre-Revolutionary days. Agriculture was the primary industry in the area and was carried on extensively for many years. Grist and fulling mills were the first to make appearance in Methuen. They were located along the Spicket River Falls, which gave the power to turn the water wheels. A cotton mill was built by Stephen Minot in 1812 and later sold to the Methuen Company. Wool hats, shoes and textiles were first made at home and later became an industry. Industrial development in this area was very slow until after the Civil War when the textile industry advanced quite rapidly. Through removals and the closing of plants, this industry has been seriously affected in Methuen and the Greater Lawrence Area. In 1917 Methuen obtained a city charter, but again resumed its township in 1921. Although primarily an industrial community, Methuen is also a mixed agricultural-residential town. The town of Methuen has a building code and a planning board which exercises subdivision control powers. A master plan has been completed and the town is a member of the Central Merrimack Valley Regional Planning District Commission.

North Andover - Prior to its incorporation in 1855, the territory now within the limits of North Andover was the first settled portion of the old town of Andover. The first industrial enterprise was started by James Scholfield in 1802. This was a mill operated by water power and engaged in the manufacture of broadcloth. In 1839, the mill was owned by Eben Sutton and was known as the North Andover Mills. The Sutton Mill, as it was later known, was operated by one family until

February of 1962. Another important firm was the Davis and Furber Machine Company which was organized in 1836. This firm manufactured textile machinery used in the making of woolen and worsted yarns. The firm became the largest builder of this type of machinery in the United States. Although North Andover is a residential town, manufacturing does play the major role in the economy of the community. The town of North Andover has a building code and a planning board which exercises subdivision control powers. A master plan has been completed and the town is a member of the Central Merrimack Valley Regional Planning District Commission.

Flood Damage Prevention Measures

Since 1936, the New England Division, Corps of Engineers has been active in a program of investigating the possibility of constructing flood control dams in the various river basins in New England. Five flood control dams have been constructed in the Merrimack drainage basin. A brief description of each follows. No other flood control projects have been authorized in the Merrimack River basin which would affect flooding in the study area.

FRANKLIN FALLS DAM

Franklin Falls Dam is located on the Pemigewasset River, the main tributary of the Merrimack River, approximately 2.5 miles upstream from Franklin and 19 miles above Concord. The dam, completed in October 1943, is a rolled earthfill with a dumped rock shell. It is 140 feet high and 1,740 feet long. Total estimated cost of the project is $8,090,000, including provision of public use facilities.

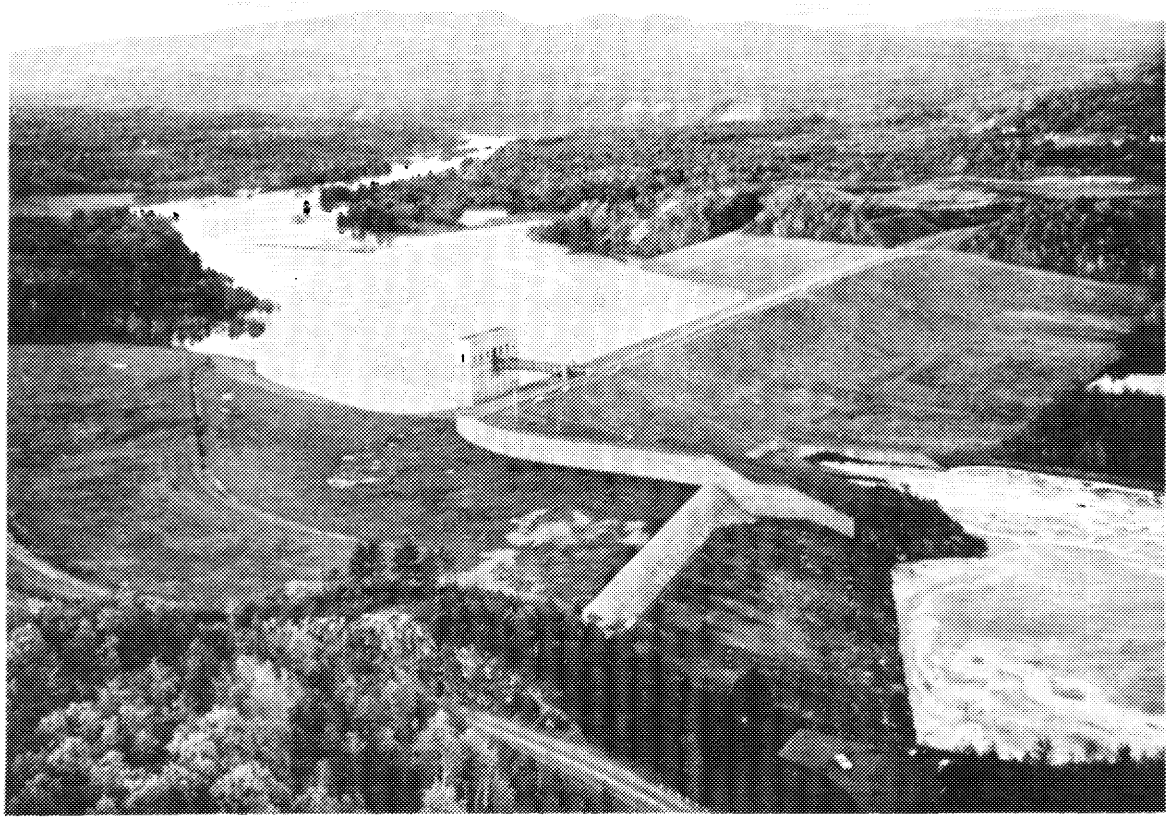
The reservoir is operated for flood control purposes and has a storage capacity of 154,000 acre-feet, which is equivalent to 2.9 inches of runoff from its drainage area of 1,000 square miles. The reservoir is normally kept empty. Control gates in the outlet structure are operated to store floodwaters in the reservoir during time of flood. When full, a narrow 2,800-acre reservoir would extend upstream about 12.5 miles.

A concrete spillway, founded on rock and 546 feet long, is located on the west abutment. The spillway, with its crest elevation 27 feet below that of the dam, would protect the dam from overtopping during passage of a Probable Maximum Flood.

The project provides flood protection along the entire length of the Merrimack River and is a key unit in the comprehensive plan of flood protection. Principal damage centers protected by its operation are Concord, Manchester, and Nashua, New Hampshire and Lowell, Lawrence, and Haverhill, Massachusetts. Since October 1943, when the reservoir reached operation status, there have been 21 significant operations to prevent downstream damages. In March 1953, the reservoir reached 76 percent of capacity and prevented damages of $8.8 million. Total damages prevented, since completion of the project, have been $15,662,000. With recurrence of the 1936 basin flood of record, the project would prevent $98.3 million in damages.

BLACKWATER DAM

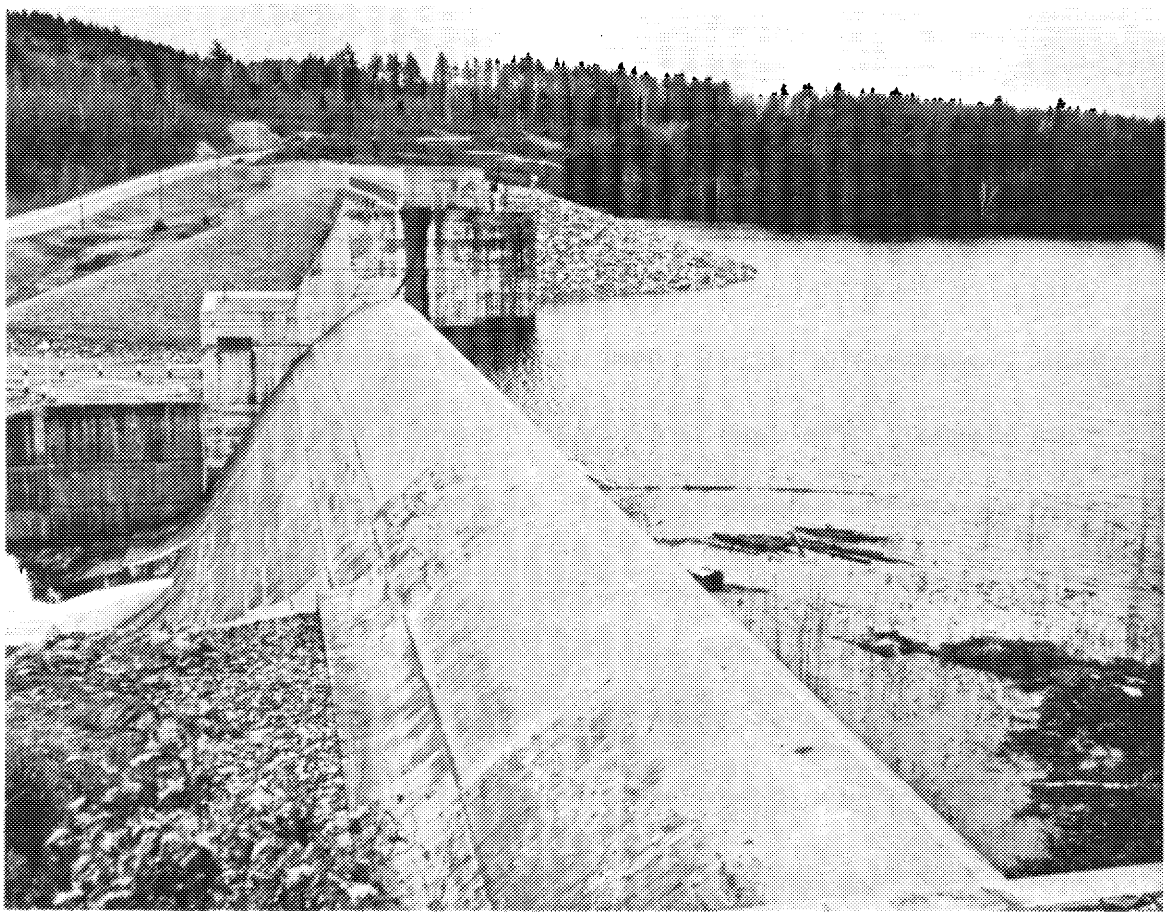
Blackwater Dam is located in the town of Webster on the Blackwater River 8.6 miles above its confluence with the Contoocook River. The dam, placed in operation in November 1941, consists of a rolled-earthfill section with a dumped rock face and a concrete gravity spillway section across the river section. The total length of the dam is 1,130 feet, of which 240 feet is along the spillway, and maximum height is 75 feet above the streambed. There are five small dikes on the west perimeter of the reservoir. The total estimated cost of the project is $1,420,000, including provision of public use facilities.



Franklin Falls Dam

The reservoir is operated for flood control purposes and has a storage capacity of 46,000 acre-feet, which is equivalent to 6.7 inches of runoff from its drainage area of 128 square miles. The reservoir is normally kept empty. Control gates, located in the spillway section, are operated to store floodwaters during time of flood. When full, a 3,140-acre reservoir would extend upstream about 7 miles with a maximum width of about one mile. The spillway, with its crest elevation 18 feet below that of the dam, would protect the dam from overtopping during a Probable Maximum Flood.

Blackwater Reservoir is operated in conjunction with Franklin Falls Reservoir to reduce floods on the Merrimack River. In addition, it is regulated to reduce flood stages on the Blackwater and Contoocook Rivers. Since its construction there have been 31 significant operations of the reservoir, the greatest of which was that of April 1969 when the reservoir was 74 percent full and prevented damages of $1,375,000. Total damages prevented since completion of the project have been $3,275,000. With recurrence of the 1936 basin flood of record the project would prevent $15.8 million in damages.



Blackwater Dam

Figure 2

EDWARD MACDOWELL DAM

Edward MacDowell Dam is located on Nubanusit Brook, a tributary of the Contoocook, one-half mile upstream from the village of West Peterborough and 14 miles east of Keene. The dam, completed in March 1950, is a rolled earthfill with a dumped rock blanket. The dam is 67 feet high and 1,030 feet long. The total cost of the project is $2,014,000, including provision of public use facilities.

The reservoir is operated for flood control purposes and has a storage capacity of 12,800 acre-feet, which is equivalent to 5.5 inches of runoff from its drainage area of 44 square miles. The reservoir is normally kept empty. Control gates in the outlet works, located near the east side of the dam, are operated to store floodwaters in the reservoir during time of flood. When full, an 840-acre reservoir would extend about 9 miles upstream.

A concrete spillway, consisting of a low weir 100 feet in length, is located in a natural saddle on the north side of the reservoir. Discharges from this spillway go into Ferguson Brook which, in turn, discharges into the Contoocook River downstream from Peterborough.

Edward MacDowell Dam

Figure 3

The project provides flood protection for Peterborough and other communities in the upper Contoocook River basin. Integrated with other Merrimack River basin reservoirs, it also provides a measure of protection to damage centers on the lower Contoocook River. There have been 29 significant operations of storage, the largest, in terms of storage utilized, being that of January 1956 when the reservoir was 58 percent full. Total damages prevented since completion of the project have been $470,000. With recurrence of the 1936 basin flood of record the project would prevent $6.2 million in damages.

HOPKINTON-EVERETT LAKES

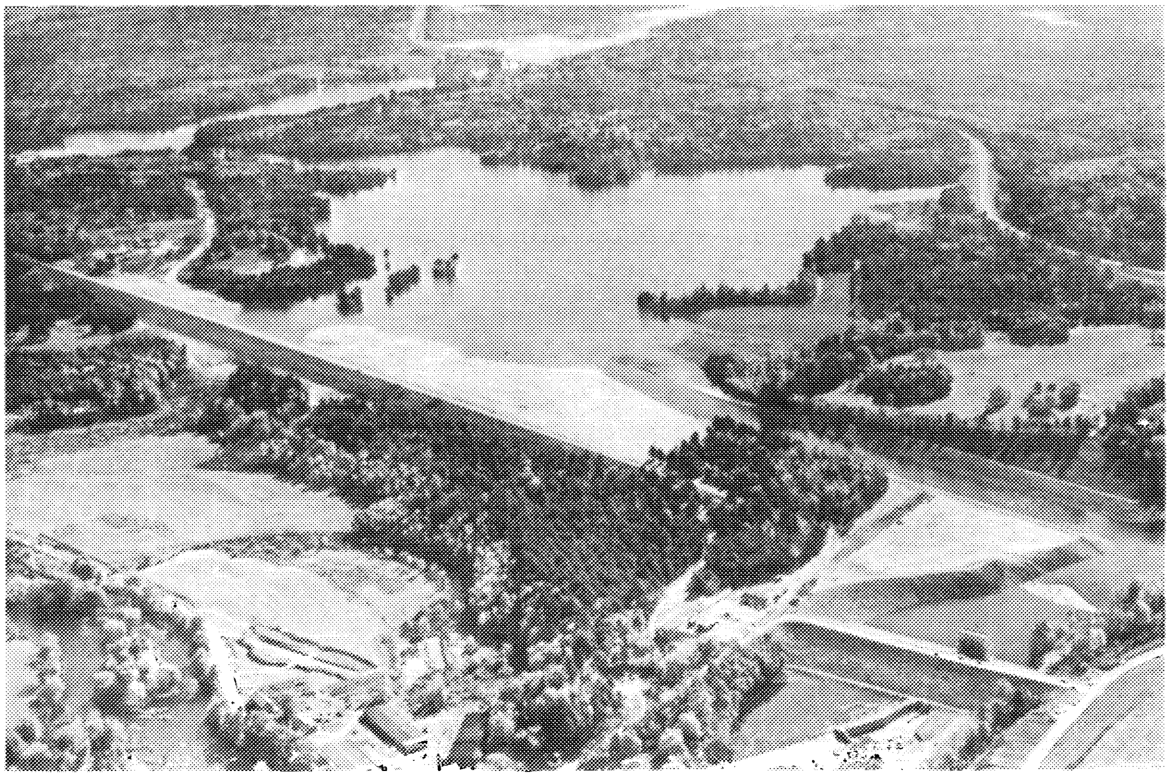
The Hopkinton-Everett Lakes are located within the towns of Hopkinton, Henniker, Weare, and Dunbarton. The project consists of a dam, canal, two large dikes, and spillway in the Contoocook River watershed and a dam, spillway, and two large dikes in the Piscataquog River watershed. The two storage areas thus formed have a capacity of 70,800 acre-feet in the Contoocook watershed and 86,500 acre-feet in the Piscataquog watershed. They are connected by a second canal, 13,900 feet long, so that the floodwaters may be transferred from a single unit. The total storage capacity of 157,300 acre-feet is equivalent to 6.0 inches of runoff from the drainage area of 490 square miles.

The Hopkinton Dam, on the Contoocook River about 500 feet upstream of the Hoague-Sprague Dam in the village of West Hopkinton, is a rolled earthfill about 76 feet high and 790 feet long. A spillway about 300 feet long is located in a saddle about 1.8 miles east of West Hopkinton.

The Everett Dam, on the Piscataquog River about 1.5 miles southeast of the village of East Weare, features a rolled earthfill about 115 feet high and 2,000 feet long with an adjacent 180-foot long concrete spillway. This spillway is at an elevation higher than that of the Hopkinton Dam spillway to prevent excessive discharge into the Piscataquog River basin.

Construction was started in April 1959 and was completed in December 1962. It required the acquisition of properties in Hopkinton, Henniker, Weare, and Dunbarton and extensive highway, utility, and cemetery relocations. The Everett Dam was operational in March 1962; the Hopkinton Dam was fully operational in December 1962. Total estimated project cost is $21,870,000, including provision of public use facilities.

The project provides general flood protection for residential, commercial, and industrial property downstream along the Contoocook and Piscataquog Rivers and along the main stem of the Merrimack River in New Hampshire and Massachusetts. With recurrence of the 1936 basin flood of record, the project would prevent damages of $51.6 million. The project has prevented damages totaling $505,000, since initiation of construction. In April 1969, the combined reservoirs reached 44 percent of capacity and prevented damage of $400,000.



Hopkinton Lake

Everett Lake

Figure 4

Major recreational developments have been completed for use at the 120-acre Everett Lake behind Everett Dam (Clough State Park) and the 160-acre Hopkinton Lake behind Hopkinton Dam.

Flood Warning and Forecasting Service

The U.S. Department of Commerce, National Weather Service, is responsible for forecasting high water on the nation's rivers and for issuing flood warnings for the protection of life and property. The National Weather Service River Forecast Center at Hartford, Connecticut is responsible for issuing flood warnings for the Merrimack River basin. A comprehensive network of rainfall and river data reporting stations have been established with cooperative observers. The flood warnings are issued by teletype simultaneously to the press services, State Police, Civil Defense and many other State and local agencies. In the event of communication failure, the State Police and Civil Defense have an emergency plan for receiving flood warnings and notifying the responsible officials.

It should be reiterated that a flood warning system is only one phase of preventative flood damage measures. The other phase is the preparation of Federal, State and local governments and private citizens to combat the impending storm. Without a sufficient storm warning and an ability to react to the warning, the residences, industrial and commercial establishments in low-lying areas will be defenseless against the raging flood waters of the Merrimack River.

In addition to the flood warning and forecasting service, the Corps of Engineers operates an Automatic Hydrologic Radio Reporting Network. This network, under computer programmed control, will immediately provide read-out information which is essential for the regulation of flood control dams. Nine stations on the Merrimack River in New Hampshire and Massachusetts report river stages. The real time print-out on the computer will assure early warning to Division personnel of high stream flows for immediate operation of the five flood control dams in the basin.

MERRIMACK RIVER

General

The Merrimack River basin extends from the White Mountain Region of New Hampshire southward into the east-central part of Massachusetts and is the fourth largest river basin in New England. It has a total drainage area of 5,010 square miles, of which 3,810 square miles are in New Hampshire and 1,200 square miles in Massachusetts. The lake and pond areas amount to about 200 square miles, or about four percent of the total basin area. The basin is approximately 134 miles long with a maximum width of 68 miles.

The topography of the Merrimack River basin varies from rugged, steep slopes and narrow valleys in the northern portion to gently rolling hills with occasional level areas and marshes in the southern portion. The northern rim of the basin lies in the White Mountain Region and contains many peaks ranging from 2,000 to 5,000 feet above mean sea level.

The basin has a long flood history with most major floods being caused by a combination of rainfall and snowmelt. Fifty-nine of the 76 largest floods recorded at Lowell, Massachusetts, since 1846 were of this type as was the record flood of March 1936.

The Stream and Its Valley

The Merrimack River is formed by the junction of the Pemigewasset and Winnipesaukee Rivers at Franklin, New Hampshire. The river flows southerly through New Hampshire into Massachusetts. (see Plate No. 1) Just south of the state line the river turns abruptly and flows northeasterly to the Atlantic Ocean near Newburyport, Massachusetts, 35 miles north of Boston. The total distance from its source at Franklin, New Hampshire to the ocean is 115 miles. The total length of the Merrimack River and the Pemigewasset River, the principal tributary, is approximately 186 miles. The total fall in the river from its headwaters in the White Mountains to the ocean is 2,700 feet or an overall average of 14.5 feet per mile. The fall in the Pemigewasset River from its source to its confluence with the Winnipesaukee River at Franklin, New Hampshire, is 2,450 feet, or an average of 34.5 feet per mile. The Merrimack River, from Franklin to the ocean, falls 250 feet, or an average of 2.2 feet per mile. The total drainage area above the Essex Company Dam at Lawrence, Massachusetts is 4,672 square miles. The net area, exclusive of the diverted parts of the Nashua and Sudbury Rivers and Lake Cochituate basins is 4,461 square miles.

Developments in the Flood Plains

Plate No. 5 is an index map of the plates that show the flooded areas of the Merrimack, Shawsheen and Spicket Rivers for the reaches covered by this report. A study of Plates No. M-1, M-2, M-3, and M-4 shows that much of the development has taken place on the left bank of the river except through Lawrence where the development is equally dense on both banks. Buildings and facilities along the reach studied,which are most vulnerable to flooding in general, are those that were constructed prior to the March 1936 flood. However, this condition has been alleviated considerably by the construction and operation of the four flood control dams and reservoirs upstream in New Hampshire. Many of these facilities would be adversely affected by the occurrence of a Standard Project Flood but would suffer only minor flooding from the Intermediate Regional Flood. Where it has not been practical to remove a facility from the flood plain flood protection measures have been taken in some cases. Some of these measures are as simple as abandoning the use of the first or ground floor. Others are more elaborate, notably the Lawrence Water Filtration Plant where a dike has been built completely around the facility to protect it from the recurrence of the March 1936 flood. Many new facilities have been or are being constructed along this reach ranging from gas stations and restaurants to the multi-million dollar Western Electric-Bell Laboratories building. Actual field investigations show that for the most part, these facilities have been designed and constructed with due consideration being given to the flood plains.

Bridges Across the Stream

Six highway bridges and one railroad bridge cross the Merrimack in the reach included in this study. Table 2 lists pertinent elevations for these structures and shows their relation to the crest of the Intermediate Regional Flood. Figures 5 and 6 show photographs of some of the bridges in the flood plain.

None of the bridges are serious obstructions to stream flow. Interstate Highway I-93 crosses the river at Methuen and Andover and Interstate Highway I-495 crosses the river at Lawrence and at Methuen to Haverhill. These highways are part of the interstate highway system and the bridges are constructed well above flood levels.

Duck Bridge at Mile 28.2 connects Lawrence with South Lawrence. The Standard Project Flood would be very close to the underclearance, while the Intermediate Regional Flood level would be well below the underclearance. The 1936 flood level rose to within a foot of the roadway elevation and the head loss was less than one foot.

The Joseph W. Carey Bridge at Mile 28.6 also connects Lawrence with South Lawrence at Parker Avenue in South Lawrence. All past floods were below the underclearance. The Intermediate Regional Flood and the Standard Project Flood would be well below the underclearance.

The Boston and Maine Railroad Bridge at Mile 28.92 crosses the river between Lawrence and South Lawrence. The 1936 flood level came between the roadway and the underclearance of the bridge. Head loss was less than a foot. The Standard Project Flood would also come between the roadway and the underclearance, but below the 1936 flood level. Head loss would be negligible. The Intermediate Regional Flood would come below the underclearance.

The O'Leary Bridge at Mile 28.95 crosses the river at Broadway. (State Route 28) Elevations generated by the Standard Project Flood and the Intermediate Regional Flood would come well below the underclearance. However, the 1936 flood level came between the underclearance and the roadway elevation. Head losses were insignificant.

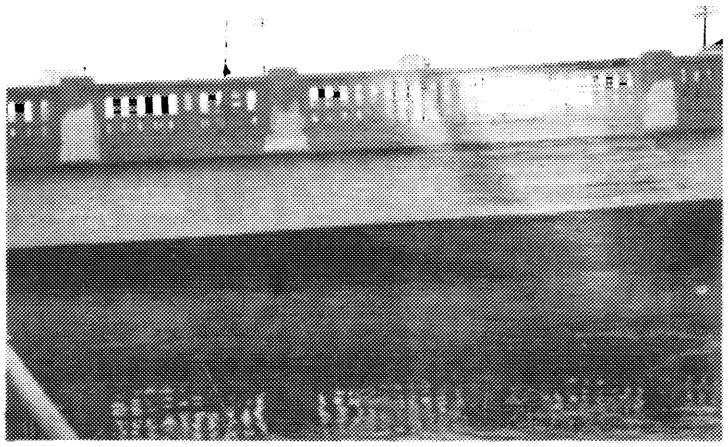
TABLE 2

BRIDGES ACROSS THE MERRIMACK RIVER

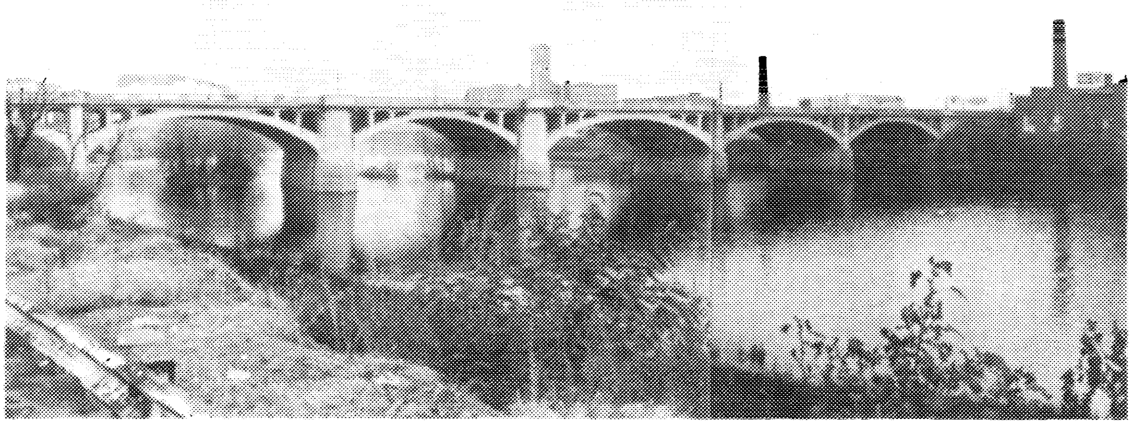
River Mile	Identification	Normal River Flow Elev. ft. msl	Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Underclearance Relation to IRF Elev. ft. msl	Above ft.	Below ft.
23.5	Route I-495	11.1	58.0	30.0	37.1	49.5	19.5	-
27.54	Route I-495 (2)	14.8	60.5	33.9	41.8	53.5	19.6	-
28.2	Duck Bridge	15.6	46.3	34.3	42.1	42.2	7.9	-
28.6	J. W. Casey Bridge	15.9	55.5	34.9	42.9	49.8	14.9	-
28.92	B&M RR Bridge	16.0	53.1 (1)	35.0	43.3	35.6	0.6	-
28.95	O'Leary Bridge	16.0	54.8	35.0	43.3	45.5	10.5	-
31.5	Route I-93	43.3	80.69	50.2	53.5	71.9	21.7	-

(1) Top of Rail

(2) Double deck bridge. Only lower deck considered.

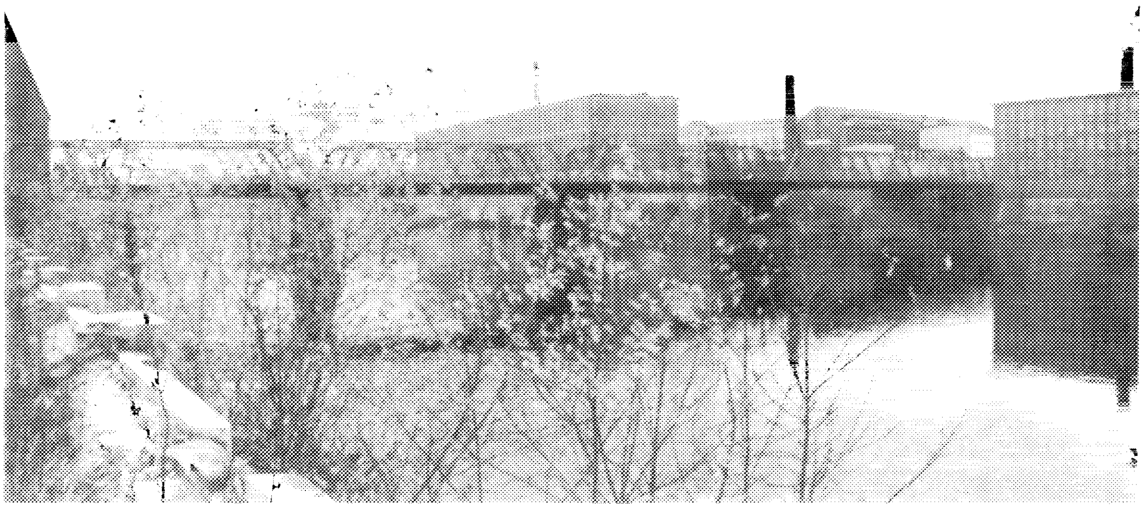


O'Leary Bridge (Broadway)
over South Canal - Merrimack River

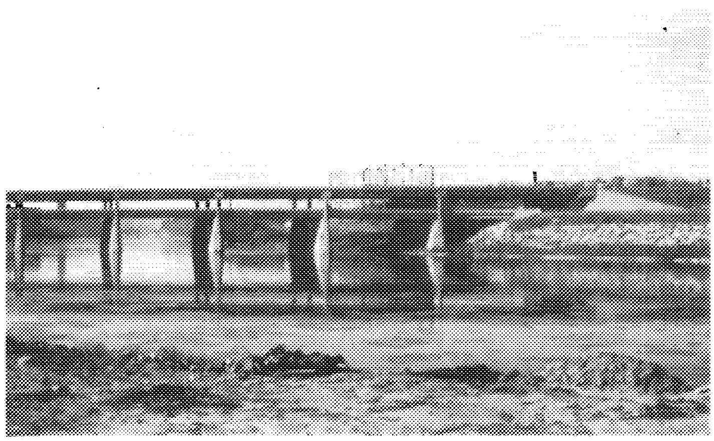


Joseph W. Casey Bridge - Merrimack River

Figure 5



Duck Bridge - Merrimack River



Interstate 495
Bridge at Lawrence - Merrimack River

Figure 6

Dams on the Merrimack River

There is only one dam on the Merrimack River in the study reach. See Figure 7. The dam, known as the Essex Company Dam, was constructed by the Essex Company and is operated by that company. Table 3 lists pertinent elevations for the dam and shows their relation to the Intermediate Regional Flood and the Standard Project Flood.

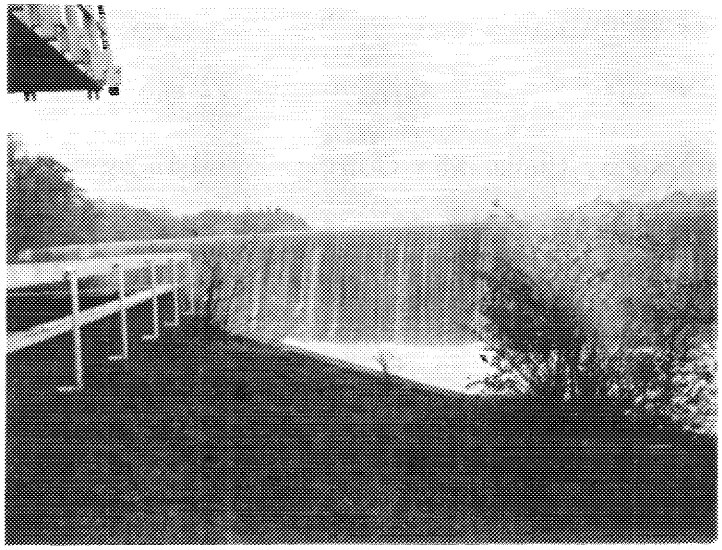
Obstructions to Flood Flows

The effect of obstructions due to the bridges has been discussed in the previous paragraphs. There are no other significant obstructions to flows in the Merrimack River reach included in this study.

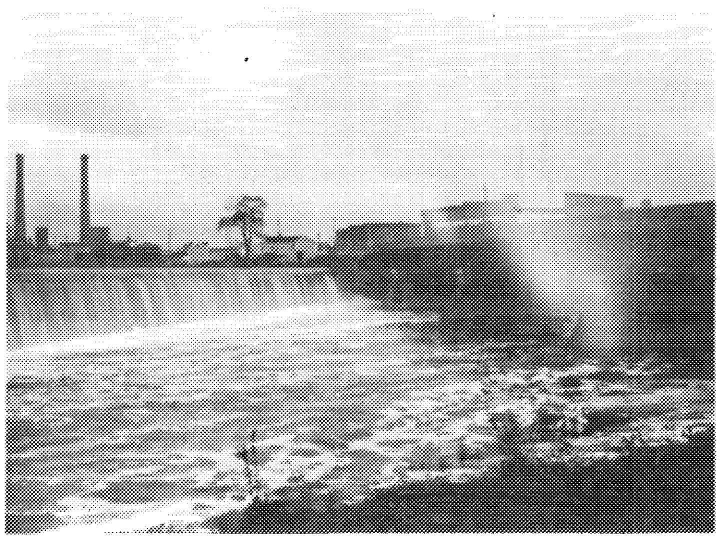
Flood Records

Records of river stages and discharges on the Merrimack River at Lawrence, Massachusetts have been maintained by the Essex Company at the Essex Company Dam since 1848.

Historical records indicate that from December 1740 to March 1896, fourteen damaging floods had occurred in the Merrimack River basin in Massachusetts. A tabulation of these floods in chronological order is given in Table 4.



Essex Co. Dam - Merrimack River
(South End)



Essex Co. Dam (North End)
O'Leary Bridge (Broadway) at right

Figure 7

TABLE 3

DAMS ON THE MERRIMACK RIVER

River Mile	Identification	Crest Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Depth Over Dam IRF ft.	Depth Over Dam SPF ft.
29.99	Essex Dam	39.2	48.5	51.8	9.3	12.6

TABLE 4

HISTORIC FLOODS

MERRIMACK RIVER BASIN

December	1740	March	1865
October	1785	October	1869
February	1807	April	1870
-	1850	-	1877
April	1852	December	1878
March	1859	April	1895
April	1862	March	1896

Data on these floods are meagre and their magnitudes are unknown.

Flood Stages and Discharges

Table 5 lists annual crests and discharges at the gage operated by the Essex Company at the Essex Company Dam on the Merrimack River at Lawrence. Only those years are shown in which the flood stage elevation was equalled or exceeded. Flood stage starts at 40.3 feet on the gage or about 45.38 feet above mean sea level which represents a flow of approximately 50,000 cfs in the Merrimack River at the Essex Company Dam. Table 6 lists the ten floods of major proportions which have occurred since 1852. Table 6 does not reflect the peak discharges or stages that would have occurred had they been modified by the four upstream flood control reservoirs since the reservoirs were constructed subsequent to the tabulated events.

Flood Occurrences

Discharge records obtained by the U. S. Geological Survey from the gage operated by the Essex Company at the Essex Company Dam in Lawrence, Massachusetts were related to experienced high waters in the Lawrence area. It has been observed that flood damage does not occur until the Merrimack River reaches a stage of 40.3 on the gage. Discharge records at Lawrence show that this has been experienced 28 times since 1852. Table 5 lists these flows and the corresponding elevation of high water in chronological order. It is noted that flood elevations reached a stage of 40.0 in April 1969.

TABLE 5

FLOOD CREST ELEVATIONS AND DISCHARGES

MERRIMACK RIVER AT LAWRENCE, MASSACHUSETTS

The Table includes peak stages during each water year that the stage was at or above flood damage elevation at the Essex Company Dam at Lawrence, Massachusetts, Mile 29.0. Drainage Area = 4,672 square miles. Zero of gage = 5.08 feet above mean sea level.

Date of Crest	Gage Heights Stage ft.	Gage Heights Elevation ft. msl	Estimated Peak Discharge cfs
April 23, 1852	44.20	49.28	108,000
March 29, 1884	41.10	46.18	60,200
February 15, 1886	40.90	45.98	59,400
April 13, 1887	40.31	45.39	51,200
March 25, 1891	40.40	45.48	52,100
March 6, 1893	40.70	45.78	57,700
April 16, 1895	42.93	48.01	89,900
March 3, 1896	43.82	48.90	105,000
July 16, 1897	40.40	45.48	52,800
February 15, 1900	41.25	46.33	63,500
April 9, 1901	42.61	47.69	84,500
March 4, 1902	41.86	46.94	73,100
March 13, 1903	40.50	45.58	53,600

TABLE 5 (Cont'd)

FLOOD CREST ELEVATIONS AND DISCHARGES

MERRIMACK RIVER AT LAWRENCE, MASSACHUSETTS

Date of Crest	Gage Heights: Stage ft.	Gage Heights: Elevation ft. msl	Estimated Peak Discharge cfs
May 1, 1904	41.03	46.11	60,600
March 30, 1905	40.35	45.43	51,800
March 29, 1920	40.90	45.98	59,500
May 1, 1923	41.38	46.46	66,200
April 9, 1924	40.63	45.71	55,200
March 31, 1925	40.82	45.90	58,200
November 6, 1927	42.23	47.31	78,900
April 14, 1932	40.29	45.37	50,900
April 20, 1933	42.08	47.16	76,200
April 14, 1934	41.07	46.15	60,800
March 20, 21, 1936	48.02	53.10	174,000
September 23, 1938	44.92	50.00	121,000
April 14, 1940	40.72	45.80	56,800
March 24, 1948	40.58	45.66	54,200
April 6, 1960	42.25	47.33	79,000
April 20, 1969	40.00	45.08	46,500

TABLE 6

HIGHEST TEN KNOWN FLOODS IN ORDER OF MAGNITUDE

MERRIMACK RIVER AT LAWRENCE, MASSACHUSETTS

Order No.	Date of Crest	Gage Height: Stage ft.	Gage Height: Elevation ft. msl	Estimated Peak Discharge cfs
1	March 20, 21, 1936	48.02	53.10	174,000
2	September 23, 1938	44.92	50.00	121,000
3	April 23, 1852	44.20	49.28	108,000
4	March 3, 1896	43.82	48.90	105,000
5	April 16, 1895	42.93	48.01	89,900
6	April 9, 1901	42.61	47.69	84,500
7	April 6, 1960	42.25	47.33	79,000
8	November 6, 1927	42.23	47.31	78,900
9	April 20, 1933	42.08	47.16	76,200
10	March 4, 1902	41.86	46.94	73,100

Rate of Rise and Duration

The Merrimack River at Lawrence is not generally a fast rising stream. Records indicate that during the flood of March 1936 the river rose approximately 3 feet above flood damage stage, which is 40.3 on the gage at the Essex Dam, from 4:00 p.m. on the 12th to 8:00 p.m. on the 13th. This represents an average rate of rise of about 0.1 feet per hour. However, within that same period, from 4:00 p.m. to 8:00 p.m. on the 13th, the river rose two feet in four hours, or 0.5 feet per hour, until it crested at stage 43.0 on the gage, where it remained for about 28 hours and then started to recede. By noon on the 17th the river had dropped below flood damage stage and remained there until noon on the 18th, when it started to rise again. It continued to rise steadily for 56 hours until it crested at 48.0 on the gage at 8:00 p.m. on the 20th, indicating a rate of rise of about 0.15 feet per hour. The water level remained at that stage for about 10 hours when it started to recede gradually at about 6:00 a.m. on the 21st and reached a level below flood damage stage at about midnight on the 25th.

It will be seen that the record flood of March 1936 occurred in two phases. During the first phase, from 4:00 p.m. on March 12th to 8:00 a.m. on March 17th, the level of the river remained above flood damage stage for a period of about 4-1/2 days. During the second phase, from noon on the 18th to about midnight on the 25th, the level of the water remained above flood damage stage for about 7-1/2 days.

Plate 4 shows graphically the duration and rate of rise of the March 1936 flood.

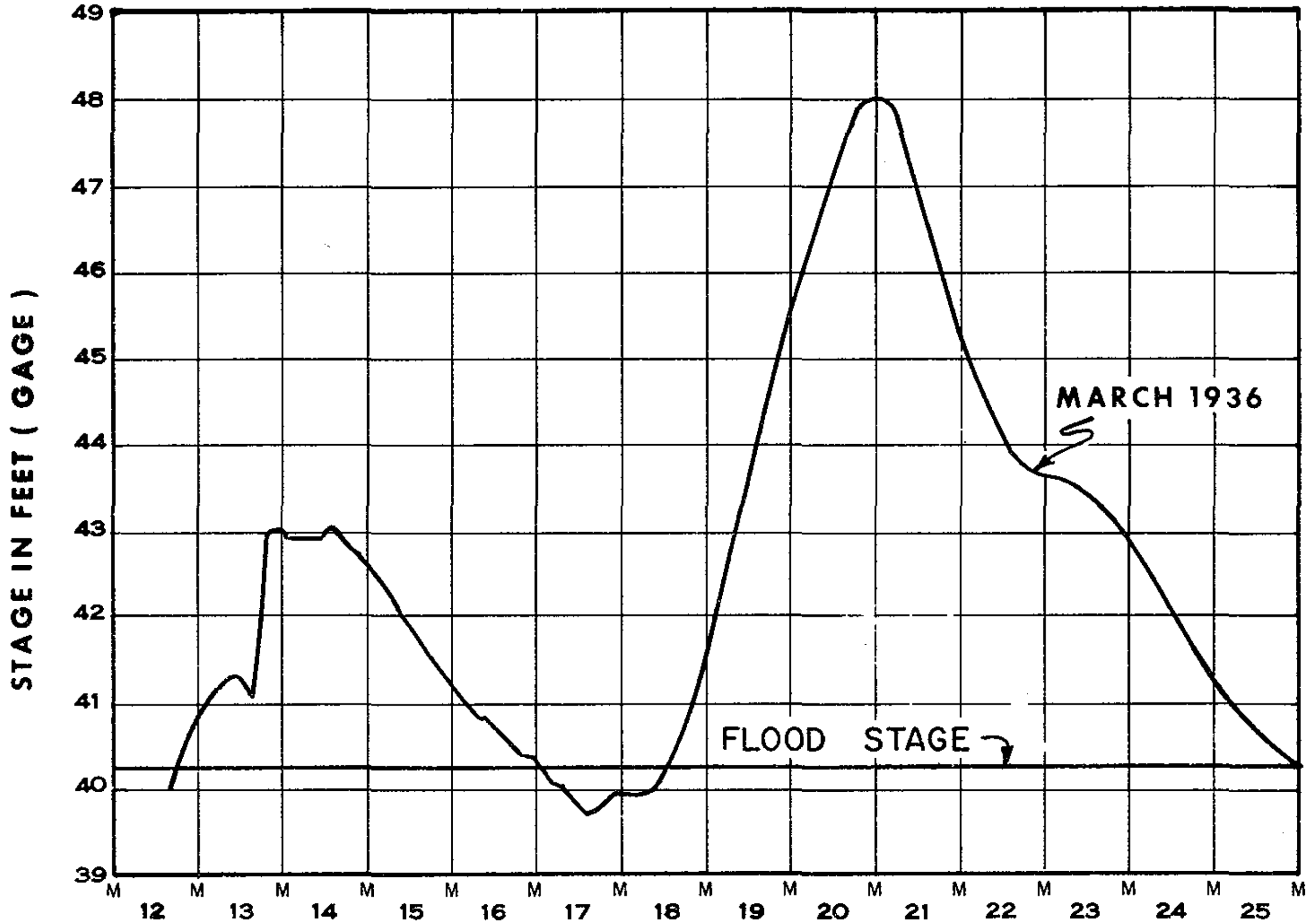
Flooded Areas and Flood Profiles

Plates M-1, M-2, M-3, and M-4 show the approximate areas along the Merrimack River in the vicinity of the study area that would be inundated by the Intermediate Regional Flood and the Standard Project Flood. The actual limits of these overflow areas on the ground may vary some from those shown on the maps because the 10-foot contour interval and scale of the maps do not permit the precise plotting of the flooded area boundaries.

Plates M-5 and M-6 show the high water marks for the flood of March 1936 and the profiles for the Intermediate Regional Flood and the Standard Project Flood discussed later in this report.

Flood Descriptions

Following are descriptions of known large floods that have occurred on the Merrimack River in Massachusetts. These are based upon newspaper accounts, historical records and field investigations.



FLOOD PLAIN INFORMATION
MERRIMACK RIVER
AT LAWRENCE, MASS.

FLOOD HYDROGRAPH
AT ESSEX CO. DAM GAGE

MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. 4

The following items were extracted from "Historical Floods in New England, " Geological Survey Water-Supply Paper 1779-M:

December 1740

NEAR MOUTH IN MASSACHUSETTS

"The snow melted, and a freshet occurred in the Merrimack River, nothing like it having been experienced there for seventy years. At Haverhill, the stream rose fifteen feet, and many houses were floated off."

February 1807

"A winter flood, reaching every river in New England, occurred in February 1807 when a great bridge over the Merrimack River at Lawrence, Massachusetts was washed away." (Browne 1915, P174)

April 1852

"The flood of 1852 on the Merrimack at Lawrence, Massachusetts was said to be the greatest flood in the lower valley of the Merrimack since 1785, in a report by the Corps of Engineers." (House Document 649, 71st Congress, 3rd Session. P. 20)

March 1859

MERRIMACK RIVER AT LOWELL, MASSACHUSETTS

This flood was reported to have a head of 10 feet and 3 inches at Pawtucket Dam, the highest flood recorded since 1834 with the single exception of the 1852 flood. (Francis 1885)

March 1865

MERRIMACK RIVER AT LOWELL, MASSACHUSETTS

A stage of 10 feet and 6 inches was recorded at the Pawtucket Dam. (Francis 1885)

October 1869

MERRIMACK RIVER AT LOWELL, MASSACHUSETTS

"The effect of this rainstorm at Lowell was to raise the water in the Merrimack 10 feet above the Pawtucket Dam. (Francis, 1885)

December 1878

MERRIMACK RIVER AT LOWELL, MASSACHUSETTS

The height of the water at Pawtucket Dam on December 12, 1878, was 10 feet 8-1/2 inches. (Francis, 1885)

March 1896

MERRIMACK RIVER IN MASSACHUSETTS

The altitude of the flood of March 3, 1896, at Lowell was 94.83 feet. (flood files in the office of the Proprietors of the Locks and Canals on the Merrimack River)

REFERENCES

Browne, G. W., 1915, Amoskeag, a history: Manchester, New Hampshire, Amoskeag Manufacturing Company.

Flood files of the Proprietors of the Locks and Canals on the Merrimack River, Lowell, Massachusetts.

Francis, J. B., 1885, Great freshets in the Merrimack River: A paper read before the Old Residents Historical Association of Lowell, Massachusetts, on November 6, 1885, and the Proprietors of the Locks and Canals on the Merrimack River, Lowell, Massachusetts.

House Document 649, 71st Congress, 3rd Session.

The following information on floods was obtained from high water data collected and published by the Massachusetts Geodetic Survey and from data collected by the New England Division of the Corps of Engineers.

Flood of November 1927

This flood was caused by a tropical disturbance which originated over Cuba and moved northward. When the disturbance reached New England, the warm, moist air from the tropics was forced over a heavier cold air mass causing precipitation in great quantities. During the 10 days preceding the storm, only light showers had fallen. However, these showers were on top of the considerable amount of rain which had fallen in the month of October. Consequently, when the storm arrived, the ground was already well saturated and surface storage areas and reservoirs were full. In New Hampshire, precipitation caused by the storm was approximately 54 percent greater than the normal amount for the month of November. As a result, the drainage basin was unable to absorb the unusually heavy rain. The heaviest concentration of rainfall in the Merrimack basin was in the northern portion where from 5 to 6 inches fell in two days. In the lower watershed, the precipitation varied from 2 to

8 inches, but only a small portion received more than 4 inches. The more extreme flows were likewise experienced in the northern area and the damages, which were estimated at about $2,365,000 (1927 prices) for the entire basin, were confined largely to the upper area.

Flood of April 20, 1933

This flood was preceded by two storms. The first occurred April 12-13th and the second on April 16-18th. Rain fell in some places on the intervening days. While the heavier rain fell during the first storm, the discharge was much higher in the second, probably caused by snow runoff. Although the peak flow at Lawrence was nearly the same as in November 1927, the peaks in the upper basin were lower. There is no record of any serious damage from this flood.

Flood of March 1936 (Flood of Record)

Warm rains and temperatures on the 11th, 12th and 13th of March rapidly melted the accumulated snows, adding greatly to the runoff. Tributaries of the Merrimack peaked on the 13th. The runoff along the tributaries, following the 13th, added materially to the flood which culminated on March 20-21st on the Merrimack River.

Runoff from rain and melted snow along the Merrimack in Massachusetts reached a peak in the eastern portion as early as the 13th of March. Normally this would have subsided without causing more than the usual freshet damage along the main channel. However, before sufficient time had elapsed for the local waters to recede, great volumes arrived from the headwaters in New Hampshire.

Records of rainfall and snow depletion show that the depletion of accumulated snows was from three to six times greater along the upper course of the Merrimack than throughout its course in Massachusetts. Rainfall from the 11th to the 21st of March was from 20 to 30 percent greater over the area of deeper snows than over the other areas.

Total damages resulting from this flood amounted to about $34,000,000, of which about $21,000,000 occurred in Massachusetts.

Flood of September 1938

This flood resulted from torrential rain accompanying a tropical hurricane which passed over the Merrimack basin at a time when the ground was already highly saturated from an earlier storm. Only minor flooding was experienced on the tributaries in the eastern portion of the basin, while the tributaries in the western portion experienced floods approaching and, in some areas, exceeding the severity of the March 1936 flood.

Flood of March 24-27, 1953

During the period of March 24-27, 1953, heavy generalized rainfall and temperatures well above the seasonal normal resulted in heavy snow melt over the northern portion of the basin. However, due to operation of the three completed flood control reservoirs in the basin, (Franklin Falls, Edward MacDowell, and Blackwater) flood flows were principally confined to the areas above Franklin Falls Dam. Operation of these reservoirs resulted in an observed peak of 54,000 cfs at Lowell as compared with a computed discharge of 78,000 cfs under natural conditions.

Flood of April 1960

The month of April began with a deep snow cover over most of the basin due to heavy March snowfall and abnormally cold temperatures. The water equivalent in the snow pack ranged up to 10 inches in the headwaters of the basin. A period of warm weather and moderate to heavy rain began on March 30 and continued with minor interruptions until April 6. At the Essex Company dam at Lawrence, the Merrimack River crested on April 6 at a stage of 42.25 feet (47.33 feet msl) with a peak discharge of 79,000 cfs.

SHAWSHEEN RIVER

General

The Shawsheen River begins near the Bedford-Lexington town line at the confluence of Kiln Brook and an unnamed brook which drains Hanscom Air Force Field. The river flows north to a point just north of Great Road where it receives flow from Elm Brook. The Shawsheen River continues to flow northerly then northeasterly through Bedford and into Billerica, through Tewksbury, Andover, Lawrence and North Andover, where it flows into the Merrimack River. The portion of the Shawsheen River studied extends from the Tewksbury town line at the southwesterly corner of Andover (Mile 37.95) to its mouth on the Merrimack River. (Mile 27.48)

The Shawsheen River and its flood plain in Andover from the Tewksbury town line to the South Lawrence town line (Mile 30.43) has been kept relatively free of encroachment as the town has grown. The short reach through the southeasterly corner of Lawrence to Mile 29.96 where the Shawsheen becomes the boundary between Lawrence and North Andover to its confluence with the Merrimack at Mile 27.48 has been more susceptible to encroachment.

The lower reach of the Shawsheen from Mile 32.54 to its mouth is affected by flood stages in the Merrimack River.

Information pertaining to floods which have occurred in the past has been obtained from records of the Massachusetts Geodetic Survey, from elevations by the Corps of Engineers, and from observations of local authorities as well as interviews with local residents. Photographs were also taken of the various reaches of the river showing details of the hydraulic structures. This section of the report discusses the flood characteristics and history of the Shawsheen River.

The Stream and Its Valley

The Shawsheen River commences at the confluence of Kiln Brook with an unnamed brook at the northeasterly corner of Hanscom Air Force Field. The river has a drainage area of 55.2 square miles at the Tewksbury-Andover town line. Its drainage area increases to 70.66 square miles at the Lawrence-Andover line about 7-1/2 miles north. In 2 miles the stream drops about 6 feet from its source to the Burlington Road Bridge, 7 feet in the next 1/2 mile, and then flattens, falling approximately 20 feet in the next 9 miles to the Tewksbury-Andover town line. From the upstream limit of this study (Tewksbury-Andover town line), the stream drops about 7 feet in the next 3 miles to the headwater of the Ballardvale Dam just north of Andover Street. From the tailwater of the Ballardvale Dam to the headwater of the Redman Card Clothing Company Dam just south of the Essex Street Bridge in Andover, a distance of about 2.5 miles, the river drops about 1.5 feet. In the next six-tenths of a mile to the Stevens Mill Dam, the stream is practically level due to the backwater of the Stevens Mill Dam. From the tailwater of the Stevens Mill Dam to the headwater of what was formerly the American Woolen Company Dam in Shawsheen Village the stream drops about 3 feet. From there for about a distance of one-tenth of a mile to the dam at the old Raytheon Plant the stream is essentially level. In the final reach, from the tailwater of this dam to the confluence of the Shawsheen River with the Merrimack River, a distance of about 3.5 miles, the stream falls about 8 feet. The downstream limit of this study is the mouth of the Shawsheen River at the Merrimack River. At this point, the total drainage area is 73.67 square miles. Plate No. 3 shows the entire watershed of the Shawsheen River as well as the study area.

The watershed of the Shawsheen River is approximately 20 miles long and 6.5 miles wide at its widest point. At the upstream end the watershed is somewhat rectangular, averaging about 4.5 miles wide and 3 miles long. The width of the watershed diminishes as the river flows through Bedford and into Billerica where the watershed is less than 2 miles wide at the Boston Road Bridge (Route 3A) in Billerica. The watershed widens again through Tewksbury for an average width of 6 miles to the Tewksbury-Andover town line, the upstream limit of this study. In the study area, the watershed is somewhat rectangular, averaging about 3 to 4 miles wide and 7.5 miles long. In general the flood plain of the Shawsheen River in the study area is rather extensive.

The first significant tributary to the Shawsheen River downstream of the Tewksbury-Andover town line is Foster's Pond outlet which enters just northeast of Lowell Junction. There are approximately 11 minor tributaries between Foster's Pond outlet and the mouth of the Shawsheen River. Pertinent drainage areas of the Shawsheen River are given in Table 7.

Developments in the Flood Plain

The three sheets which show the flooded areas along the

TABLE 7

DRAINAGE AREAS IN THE SHAWSHEEN RIVER WATERSHED

Location	River Mile	Drainage Area sq. mi.
Tewksbury-Andover T/L	37.95	55.20
Lawrence-Andover T/L	30.43	70.66
Lawrence-North Andover T/L	29.96	70.98
Merrimack River	27.48	73.67

Shawsheen River are designated as Plates SH-1, SH-2 and M-2 on the index map. (Plate 5)

From the upper end of the study area at Mile 37.95 downstream to Foster's Pond outlet at Mile 35.76, the flood plain varies in width from about one-tenth of a mile to about a half a mile. Most of the flood plain is on the right bank and is mostly in the low lying swampy areas. Some industrial and residential development has taken place in the flood plain and would be inundated by the Intermediate Regional Flood. The flood plain on the left bank is very narrow since the ground rises very rapidly. The width of the flood plain along this reach on the left bank averages about one-tenth of a mile that would be flooded by the Intermediate Regional Flood. There are no significant developments on the left bank of this reach.

Foster's Pond Outlet enters the Shawsheen River at the downstream end of this reach and extends about one mile southeasterly to Foster's Pond. This tributary creates flooding, during the occurrence of the Intermediate Regional Flood, of an area approximately one mile long and an average of three-tenths of a mile wide. Some development has taken place on the right bank in the Ballardvale section of Andover where River Road runs from Andover Street to

Lowell Junction, a distance of almost a mile. A number of residences have been constructed on both sides of River Road. These would be flooded during the occurrence of an Intermediate Regional Flood as well as about half the length of River Road itself.

From the dam at Andover Street to about Mile 34.0, the flood plain widens to about a half mile at Pomps Road. This is a low swampy area with little development.

From Mile 34.0 to the old Stevens Dam at Mile 31.94 there is some development along both banks. However, very little of it would be affected by either the Intermediate Regional Flood or the Standard Project Flood.

Just downstream from Stevens Street, on North Main Street in Andover, a shopping center known as Shawsheen Plaza has been constructed on the right bank near the North Main Street Bridge. An examination of Plate SH-1 shows that this shopping center has been constructed in the flood plains. Figure 22 includes a photograph taken in front of the De Moulas Supermarket and the Supreme Cleaners showing the heights that the Intermediate Regional Flood and the Standard Project Flood would reach at this location. Directly across the river, on the left bank, a complex of garden-type apartments has been constructed. Although this complex is on the flood plain it would be vulnerable only to the Standard Project Flood.

Shawsheen Village, which suffered considerable damage during the March 1936 flood, is still subject to flooding. (see Figure 23)

Another shopping center, known as the North Andover Shopping Mall, has been constructed near the Winthrop Avenue Bridge in the flood plain on the right bank. (see Figure 22)

Figure 24 also shows facilities that have been constructed in the flood plain adjacent to the Massachusetts Avenue-Loring Street Bridge.

From the Stevens Dam to the mouth of the Shawsheen at the Merrimack River, there has been a great deal of industrial and residential development. This reach is subject to backwater flooding from the Merrimack during peak flows. The occurrence of the Intermediate Regional Flood would cause considerable damage.

There are many highway bridges crossing the Shawsheen River in the study reach. The approaches to some of them would be flooded by the Intermediate Regional Flood. Table 8 shows the relationship between the bridge elevations and the Intermediate Regional Floods.

Bridges Across the Stream

There are 13 highway bridges, 1 utility bridge and 5 railroad bridges which cross the Shawsheen River in the reach included in this study. Table 8 lists pertinent elevations for some structures and shows their relation to the crest of the Intermediate Regional Flood. Figures 8, 9, 10, and 11 show photographs of some of the bridges.

Interstate Route 495 has been completed recently. In Lawrence this route crosses the Merrimack at the mouth of the Shawsheen River. Because of Route I-495, the Shawsheen River has been relocated at its mouth for a distance of about 600 feet. The relocated Shawsheen reaches the Merrimack through a culvert with an effective waterway measuring 45 feet by 16 feet. The relocated river passes under Merrimack Street through the culvert and eliminates the Sutton Street Bridge. Both the Intermediate Regional Flood and the Standard Project Flood would inundate the roadway at this location and consequently would not pose an obstruction to flood flows.

Farther south, the Shawsheen has been again relocated and passes under I-495 at approximately Mile 28.7 through a culvert of the same size. The elevation of the roadway would be about 10.3 feet above the Standard Project Flood and about 18.2 feet above the

Intermediate Regional Flood. This culvert could cause considerable obstruction to flood flows.

North Parish Road, at river Mile 29.0, is an abandoned road and accessible only to foot traffic. An old two-span stone masonry bridge crossed the river at one time. One span, approximately 20 feet long, has been washed away. Rubbish and debris collecting at this point could conceivably cause obstruction to low flows. Views of this bridge are shown on Figure 8.

Many of the remaining bridges would offer some obstruction to flood flows, as both the Intermediate Regional and Standard Project Floods will come between the roadways and underclearances.

Dams on the Shawsheen River

There are five dams in the study reach of the Shawsheen River. Views of some of these dams are given on Figure 12. Table 9 lists pertinent elevations for the dams and shows their relation to the Intermediate Regional Flood and the Standard Project Flood. A study of the profile and Table 9 indicates that these dams have little effect on flood flows.

TABLE 8

BRIDGES ACROSS THE SHAWSHEEN RIVER

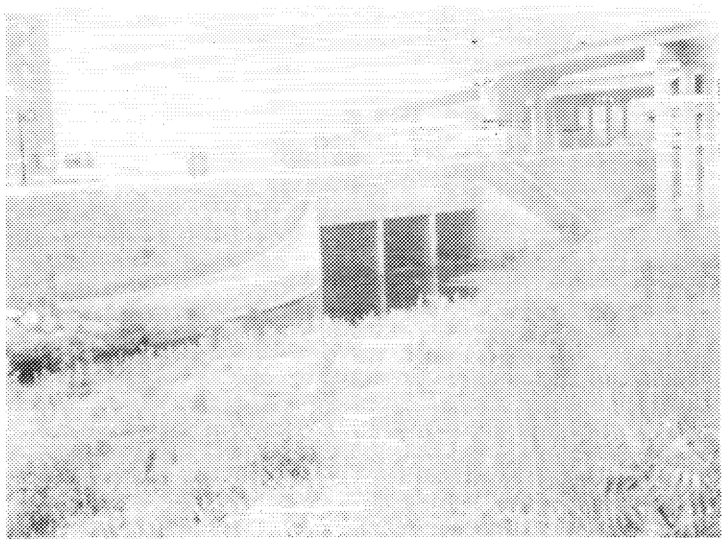
River Mile	Identification	Normal River Flow Elev. ft. msl	Floor Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Underclearance Relation to IRF Elev. ft. msl	Above ft.	Below ft.
27.72	Merrimack St.	14.5	28.7	33.8	41.7	25.8	-	8.0
27.89	B&M RR	15.5	41.9	33.8	41.7	34.6	0.8	-
28.03	Mass. Ave.	16.0	34.0	33.8	41.7	28.6	-	5.2
28.70	Route I-495	18.1	52.0	33.8	41.7	26.3	-	7.5
29.00	North Parish Rd.	19.0	33.0	33.8	41.7	28.7	-	5.1
29.95	Winthrop Ave.	20.5	33.1	33.8	41.7	30.4	-	3.4
31.08	Utility Bridge	25.8	28.7(1)	33.8	41.7	28.1	-	5.7
31.15	Haverhill St.	25.8	33.5	34.0	41.7	31.4	-	2.6
31.19	Balmoral St.	27.1	36.9	34.3	41.7	34.3	0	0
31.87	North Main St.	29.9	38.1	36.7	41.7	34.5	-	2.2
32.00	Stevens St.	41.0	47.6	45.5	46.5	45.0	-	0.5
32.36	Essex St.	41.0	51.4	48.0	49.0	47.8	-	0.2
33.17	Central St.	55.3	64.7	61.0	62.0	62.1	1.1	-
35.06	Andover St.	70.0	76.5	74.0	75.2	73.7	-	0.3
36.93	Route I-93	74.0	96.5	78.9	80.0	93.0	14.1	-

(1) Top of Pipe

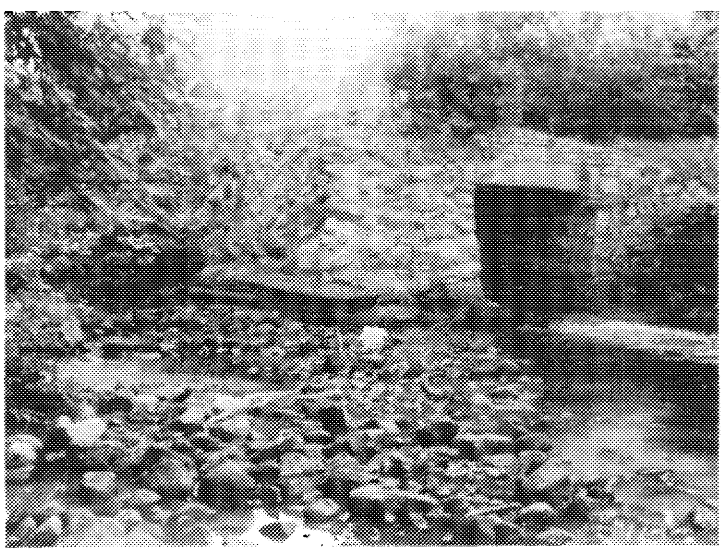
TABLE 9

DAMS ON THE SHAWSHEEN RIVER

River Mile	Identification	Crest Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Depth Over Dam IRF ft.	Depth Over Dam SPF ft.
31.08	Dam	25.9	33.8	41.7	7.9	15.8
31.17	Formerly American Woolen Co. Dam	26.4	34.0	41.7	7.6	15.3
31.94	Stevens Mill	40.2	45.0	46.0	4.8	5.8
32.54	Redman Card Clothing Co.	52.4	59.0	60.0	6.6	7.6
35.00	Ballardvale	66.3	74.0	75.0	7.7	8.7

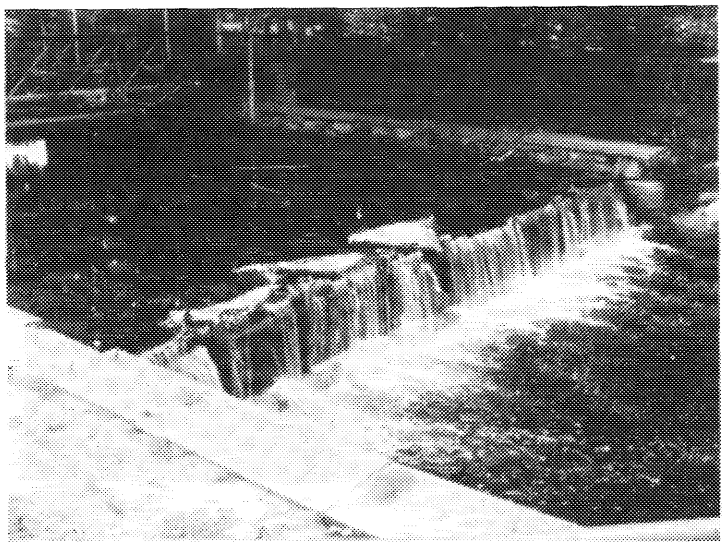


Culvert under Merrimack St. looking
Downstream - Shawsheen River

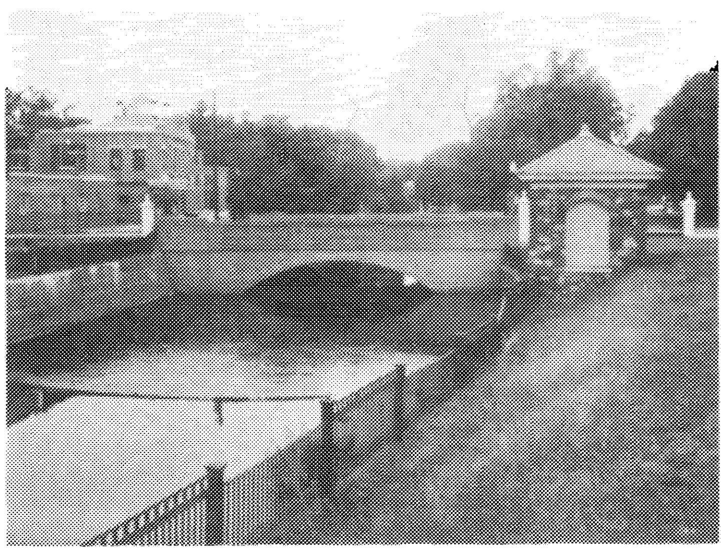


North Parish Rd. Bridge looking Upstream - Shawsheen River -
Note demolished span at left

Figure 8

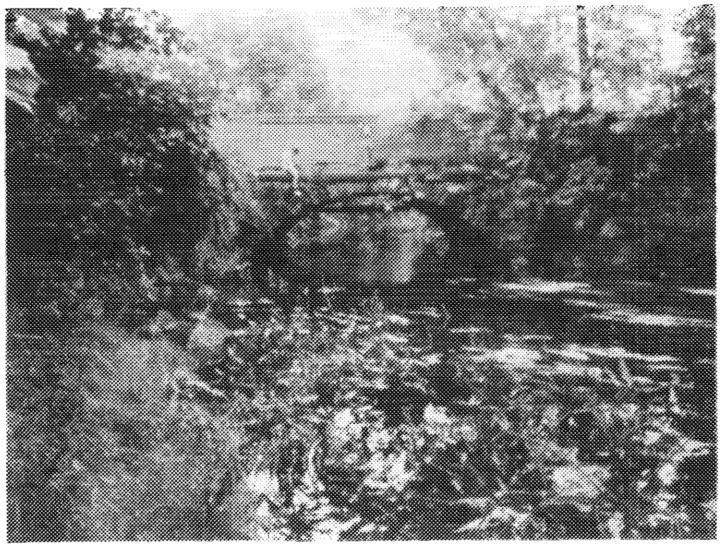


Pipe Bridge and Dam at Mile 31.08 - Shawsheen River

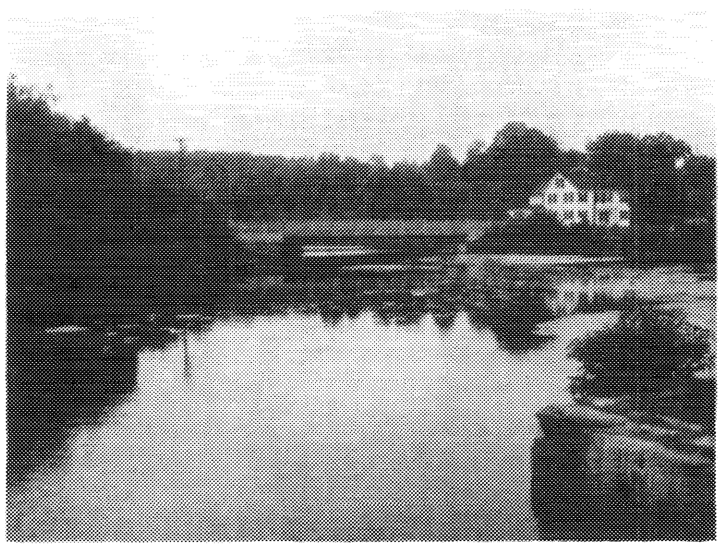


Haverhill St. Bridge - Shawsheen River
Note former American Woolen Co. Dam in foreground

Figure 9

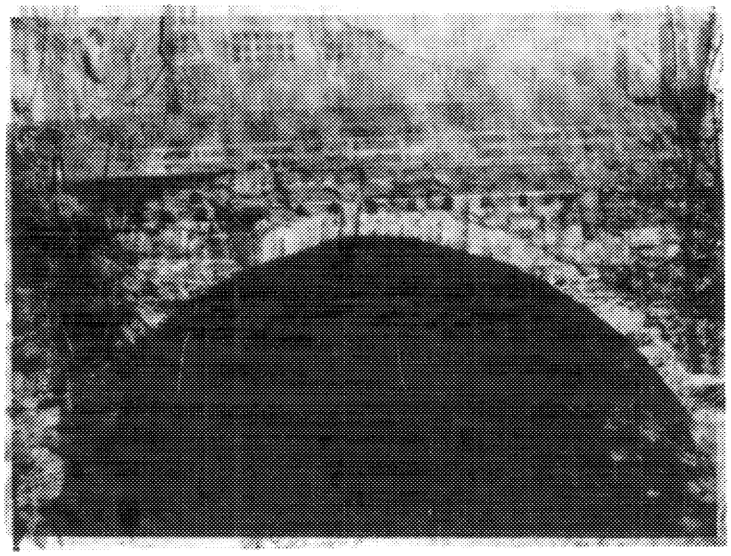


Essex St. Bridge looking Downstream -
Shawsheen River



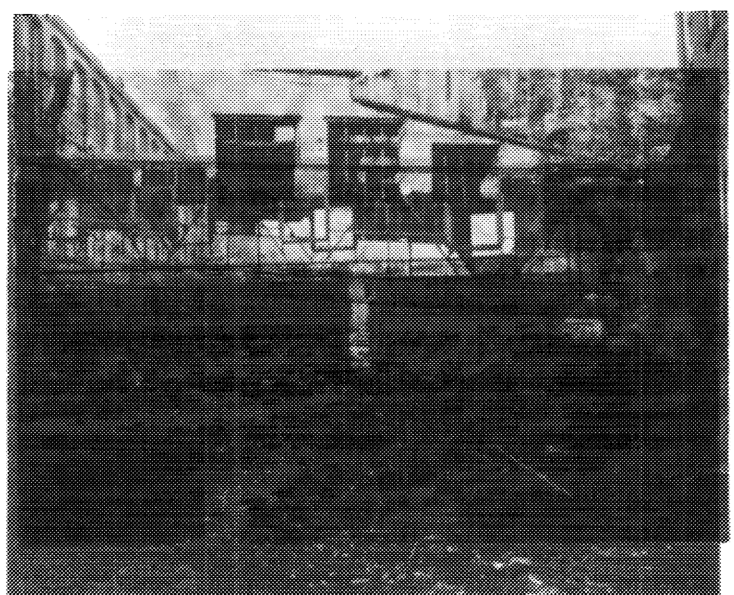
Andover St. Bridge looking Upstream -
Shawsheen River

Figure 10



Osgood Street Bridge - Looking downstream -- Spicket River

Ballardvale Dam - Shawsheen River



Footbridge near Redman Card Clothing Co. Dam in Background - Shawsheen River

Building over Spicket River below Osgood Street

Figure 13

Figure 12

Obstructions to Flood Flows

The effect of obstructions due to dams and bridges or bridge approaches has been discussed in the previous paragraphs. There are no other significant obstructions to flows in the Shawsheen River reach included in this study.

Flood Records

There are no records of stream stages or discharges available in the lower reach where the majority of flood damage occurs. Information pertaining to floods has been obtained from records of the Massachusetts Geodetic Survey, from observations of local authorities as well as interviews with local residents. Information obtained by field investigations and office computations was used to establish the profile for the March 1936 flood.

Flood Occurrences

The investigation indicates that major floods have occurred with less frequency on the Shawsheen River than on the main stream of the Merrimack River.

Flooded Areas and Flood Profiles

Plates SH-1, SH-2, and M-2 show the approximate areas along the Shawsheen River that would be inundated by the Intermediate Regional Flood and the Standard Project Flood. The actual limits of the overflow areas on the ground may vary somewhat from those shown on the maps because the 10-foot contour interval and scale of the maps do not permit precise plotting of the flooded area boundaries.

Plate SH-3 shows the high water for the flood of March 1936. Also shown are the profiles for the Intermediate Regional and Standard Project Floods which are discussed later in this report.

Flood Descriptions

The following is a description of one flood on the Shawsheen River. Description of other floods are included with the discussion of past floods on the Merrimack River.

Flood of March 1936 - (See Pages 99 and 100)

This flood is the flood of record on the Shawsheen River as well as on the entire Merrimack basin. Rain and warm temperatures on March 11, 12, and 13, produced higher waters along the upper portion of the river south of Shawsheen Village in Andover than occurred a week later. The depletion of snow cover during this period added greatly to the total runoff. On the lower portion of the river north of Shawsheen Village all high water marks of the 13th were obliterated by the higher waters of the 20th. This was caused by the arrival, along the lower reaches of the Merrimack, of the waters from north of the State line, causing backwater flooding on the Shawsheen. The backwater from the Merrimack and the unusual discharge from the upper Shawsheen River combined to inundate the lowlands through which the Shawsheen flows to reach the Merrimack. Backwater from the Merrimack contributed to the flood conditions along the Shawsheen as far south as Andover, a distance of about five miles from the mouth. A free runoff into the Merrimack River would have prevented much of the flooding.

SPICKET RIVER

General

The Spicket River begins near the Arlington Mill Reservoir in Salem, New Hampshire, at the confluence of the outlet from the Wheeler Dam (Arlington Mill Reservoir), the outlet from Captain Pond, and Providence Hill Brook which picks up the runoff from Hog Hill Brook. The river flows south about one mile where it receives flow from Widow Harris Brook. It continues to flow southerly, picking up flow from minor tributaries, to a point near the New Hampshire-Massachusetts stateline where it picks up local drainage in the vicinity of Rockingham Park racetrack and an unnamed tributary east of the park; it then flows southerly to its junction with Policy Brook near the stateline. The Spicket River then flows southeasterly through Methuen to the Lawrence cityline then easterly and southerly through Lawrence to the Merrimack River at Mile 27.85. The portion of the Spicket River covered by this study starts at the New Hampshire-Massachusetts stateline and the boundary between Salem, New Hampshire and Methuen, Massachusetts. The drainage area of the Spicket River at the stateline is approximately 59.1 square miles, at Mile 33.14.

In the upper reach of the study area, the Spicket River and its flood plain have been kept relatively free of encroachment as the town of Methuen has grown. This is probably due in a large measure to the width of the flood plain and the numerous marshy areas. With the siting of Interstate Highway 93 up through the center of the flood plain, the area should be more susceptible to encroachment by industrial or commercial development.

Information pertaining to floods which have occurred in the past has been obtained from records of the Massachusetts Geodetic Survey, from observations by the Corps of Engineers, and from observations of local authorities as well as interviews with local residents. Photographs were also taken of the various reaches of the river showing details of the hydraulic structures. This section of the report discusses the flood characteristics and history of the Spicket River.

The Stream and Its Valley

The Spicket River commences at the confluence of the Providence Hill Brook and the outlets from Captain Pond and the Arlington Mill Reservoir in Salem, New Hampshire. The river has a drainage area of 59.11 square miles at the state line and its drainage area increases to 72.0 square miles at the Methuen-Lawrence town line. At the mouth of the Spicket River, the drainage area is approximately 74.5 square miles. In approximately 8 miles the stream gradient drops about 10 feet from its sources to the Massachusetts stateline. The gradient remains almost level in the next 1.9 miles to the dam at Lowell Street. From the dam at Lowell Street to the Malden Mills Dam, the gradient drops 10 feet in approximately three-tenths of a mile and then flattens, falling approximately 1 foot in the next 1.1 mile to the dam below Osgood Street. From there the gradient drops approximately 5 feet in the next mile and 25 feet in the last mile to the mouth of the Spicket on the left bank of the Merrimack River, the downstream limit of the study. Plate 2 shows the entire watershed of the Spicket River as well as the study area.

The watershed of the Spicket River is approximately 15 miles long by 5 miles wide. At the upstream end of the Spicket in the New Hampshire portion of the drainage area, the terrain is very hilly and contains numerous large ponds and lakes. The watershed area, from the stateline going downstream approximately 1.6 miles to the B & M Railroad bridge, is relatively flat with numerous swampy areas. The flood plain in this reach is rather extensive while downstream the flood plain narrows due to the steeper adjacent topography.

The first significant tributary to the Spicket River downstream of the stateline is Harris Brook which enters just south of the Hampshire

Road Bridge. World End Pond Outlet is next to enter just downstream approximately 0.4 mile. One other large tributary, Mystic Pond Outlet, enters the Spicket River at the bridge on the eastbound ramp of Highway 213. Pertinent drainage areas of the Spicket River are given in Table 10.

TABLE 10

DRAINAGE AREAS IN THE SPICKET RIVER WATERSHED

Location	River Mile	Drainage Area Sq. Mi.
New Hampshire Stateline	33.14	59.11
Methuen-Lawrence Townline	30.07	72.00
Merrimack River	27.85	74.42

Developments in the Flood Plain

The sheets which show the flooded areas along the Spicket River are designated as Plates SP-1, SP-2, and M-2 on the index map, Plate 5.

Although there are no records of significant flood damages on the river, it can be seen from a study of Plates SP-1, SP-2, and M-2 that there are areas along the river that would be vulnerable to an Intermediate Regional Flood and a Standard Project Flood.

The major flood plain along the reach studied lies between the New Hampshire state line and the railroad bridge at river Mile 31.5. (see Plate SP-2) This area, in Methuen, is mostly low lying swampy ground. Considerable development, mostly residential, has taken place on the high ground bordering the flood plain and is not subject to flooding. However, several highways run through the flood plain, specifically Hampshire Road, Cross Street, Pelham Street and Interstate Highway I-93. Some development, mostly residential, has taken place on Hampshire Road, Cross Street and Pelham Street. Some short stretches of these highways would be inundated by the Intermediate Regional Flood and the Standard Project Flood, with inevitable flooding of the existing developments.

Since the completion of I-93 with its ready accessibility, there are increasing indications of contemplated industrial development in the flood plain. The Hampshire Road Bridge over Policy Brook (relocated Spicket River) at the New Hampshire state line was completely inundated by the March 1936 flood and would also be inundated by the Intermediate Regional Flood and the Standard Project Flood. Just over the state line in New Hampshire at the Hampshire Road Bridge a new brick office and warehouse type building has just been completed. Figure 25 shows a view of the front entrance to the building and indicates the heights to which the Intermediate Regional Flood and the Standard Project Flood would reach. It can be seen that the Intermediate Regional Flood would be approximately level with the ground surface at the front entrance. The Standard Project Flood would be about two feet higher and would be at least a foot higher than the floor elevation.

In the same area, but in Methuen, Massachusetts, the V & P Trucking Center has been constructed and is in operation. This consists of an office building, garages, gasoline pump island, a large paved area and a paved road leading to Hampshire Road. Although Figure 25 shows that only the Standard Project Flood would reach the floor of the office building, the paved area would be covered by about a half foot of water. However, the access road from Hampshire Road would be inundated by the Intermediate Regional Flood, especially at its intersection with Hampshire Road. Although it appears that this facility is reasonably safe from floods, the fact remains that as much as four feet or more of fill was required to bring the area above the flood levels. The area thus formed constitutes an obstruction to flood flows in the flood plain. Although this facility may not cause a significant obstruction, multiple facilities could. There is every indication that more facilities will be constructed in this area.

Downstream of the railroad bridge at Mile 31.5, the flood plain is relatively narrow. No significant flood losses have been reported although there is considerable development along this stretch with much encroachment of the flood plain. The narrow streets and the density of the developments could cause considerable obstruction to a major flood. The calculated Intermediate Regional Flood profile for this reach is the same as the high water profile of the March 1936 flood which was the flood of record. The Standard Project Flood profile for this reach is about two feet higher than the flood of record. The Standard Project Flood is a theoretical flood based upon the worst possible meteorological conditions as defined elsewhere in this report. This flood is delineated on the plans and although the chances of its occurrence are slight, nevertheless, the area encompassed by this flood should not be neglected in the resolution of flood problems or in the delineation of any flood zoning.

Bridges Across the Stream

Twenty-one highway bridges (including one carrying a railroad spur track) and four railroad bridges cross the Spicket River in the reach included in this study. Table 11 lists pertinent elevations for these structures and shows their relation to the Intermediate Regional Flood and the Figures 13, 14, 15, and 16 show photographs of some of these bridges.

A study of the profile indicates that the bridges do not present serious obstructions to flood flows.

The construction of Interstate Route I-93 required relocation of the Spicket River from its confluence with Policy Brook at the New Hampshire stateline to about river mile 32.3 or about three quarters of a mile northwest of the center of Methuen. The relocated section runs parallel to I-93 on the northeast side. The effect of the relocated section of the river and of I-93 on the flood plain is shown on SP-2. Two bridges on I-93 cross the Spicket River in this area. The underclearances of both bridges are well above the Intermediate Regional Flood and the Standard Project Flood and offer no restriction to flood flows.

The underclearances of about half of the remaining bridges would come above the Intermediate Regional Flood and would offer no restriction to flood flows. Some restriction to flood flows would be offered by the other bridges since their underclearances would vary from 1 to 6 feet below the Intermediate Regional Flood.

From its mouth, extending about a mile upstream, the Spicket River is subject to backwater flooding from the Merrimack River. This has the effect of raising the elevation of the Intermediate Regional Flood and the Standard Project Flood in this reach to an elevation higher than it would be if a free flow to the Merrimack was possible. This condition is similar to that which occurs on the Shawsheen River and which was discussed previously. All the bridges in this reach up to and including the Haverhill Street Bridge would be affected by the Intermediate Regional Flood or the Standard Project Flood to a greater or lesser degree as shown on the profile. Plate No. SP-3.

Continuing upstream, the underclearances of the East Haverhill Street and Jackson Street Bridges would be above the Intermediate Regional and Standard Project Floods.

The underclearance of the Short Street Bridge at Mile 28.9 would be below both the Intermediate Regional Flood and the Standard Project Flood.

The Intermediate Regional Flood would come between the roadway and the underclearances of the Lawrence Street, Bennington Street, Hampshire Street, Spruce Street and Broadway Bridges. The Broadway Bridge at Mile 29.8 would be completely inundated by the Standard Project Flood.

Broadway (State Route 28) crosses the Spicket River at two more locations in Methuen. The underclearance of the bridge at Mile 30.6 is well above both the Intermediate Regional Flood and the Standard Project Flood. However, the underclearance of the Broadway Bridge at Mile 30.95 is less than a foot above the Intermediate Regional Flood and slightly more than a foot below the Standard Project Flood. The roadway would be above both floods.

The lowest point of the Osgood Street Bridge is almost 5.5 feet above the Intermediate Regional Flood and more than 2 feet above the Standard Project Flood.

Lowell Street Bridge crosses the Spitket River in the center of Methuen. The underclearance of this bridge would come less than a foot below the Standard Project Flood. Head losses would be less than a foot. The bridge roadway would be about 4.0 feet above the Intermediate Regional Flood and about 2.0 feet above the Standard Project Flood.

The Hampshire Road Bridge crosses the river near the New Hampshire stateline. Its underclearance would be about 3.5 feet below the Intermediate Regional Flood and 5.4 feet below the Standard Project Flood. The bridge roadway would be completely inundated by both floods.

TABLE 11

BRIDGES ACROSS THE SPICKET RIVER

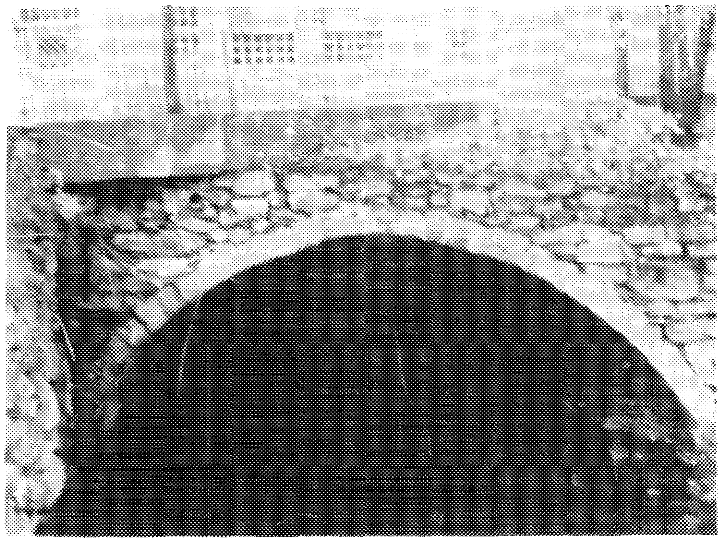
River Mile	Identification	Normal River Flow Elev. ft. msl	Floor Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Underclearance Elev. ft. msl	Underclearance Relation to IRF Above ft.	Underclearance Relation to IRF Below ft.
27.95	Canal St.	12.0	51.6	34.0	42.1	41.6	7.6	-
28.01	Highway Bridge	13.7	29.8	34.0	42.1	26.9	-	7.1
28.01	RR Spur	13.7	45.2	34.0	42.1	38.9	4.9	-
28.12	Garden St.	19.8	37.6	34.0	42.3	30.0	-	4.0
28.32	Haverhill St.	29.0	45.0	36.0	42.8	38.5	2.5	-
28.70	E. Haverhill St.	35.9	55.1	43.0	45.6	49.7	6.7	-
28.78	Jackson St.	37.1	55.6	45.2	47.0	51.6	6.4	-
28.90	Short St.	37.8	49.6	45.5	47.8	45.8	0.3	-
29.08	Lawrence St.	38.1	50.8	45.8	48.0	44.9	-	0.9
29.26	Bennington St.	38.5	49.3	46.0	48.1	45.3	-	0.7
29.45	Hampshire St.	39.0	49.1	46.2	48.4	45.2	-	1.0
29.60	Spruce St.	39.5	49.1	47.0	49.0	44.8	-	2.2
29.81	Broadway	40.0	51.5	49.0	51.3	48.4	-	0.6

(Continued on page 83)

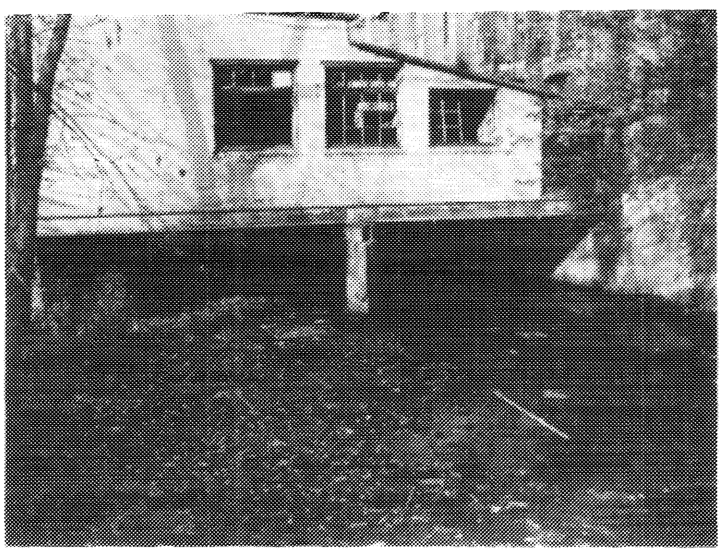
TABLE 11 (Cont'd)

BRIDGES ACROSS THE SPICKET RIVER

River Mile	Identification	Normal River Flow Elev. ft. msl	Floor Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Underclearance Elev. ft. msl	Underclearance Relation to IRF Above ft.	Underclearance Relation to IRF Below ft.
29.85	Highway Bridge	43.0	59.0	58.5	60.1	57.6	-	0.9
30.06	RR Spur	54.8	59.9	60.0	62.2	57.5	-	2.5
30.32	RR Spur	55.0	61.2	60.1	62.8	59.2	-	0.9
30.42	Highway Bridge	55.2	62.6	61.0	63.2	59.7	-	1.3
30.62	Broadway	55.2	73.7	61.0	63.3	66.9	5.9	-
30.95	Broadway	55.9	66.9	62.0	64.0	62.9	0.9	-
31.22	Osgood St.	67.5	80.2	72.8	74.8	77.2	4.4	-
31.32	Lowell St.	104.0	114.8	108.6	110.2	107.6	-	1.0
31.52	B&M RR	104.0	113.1	110.0	112.0	107.4	-	2.6
32.0	Route I-93 S	104.0	124.1	110.0	112.3	119.3	9.3	-
32.22	Route I-93 N	104.0	124.0	110.3	112.5	120.1	9.8	-
33.12	Hampshire Rd.	104.0	110.6	112.0	114.0	108.7	-	3.3

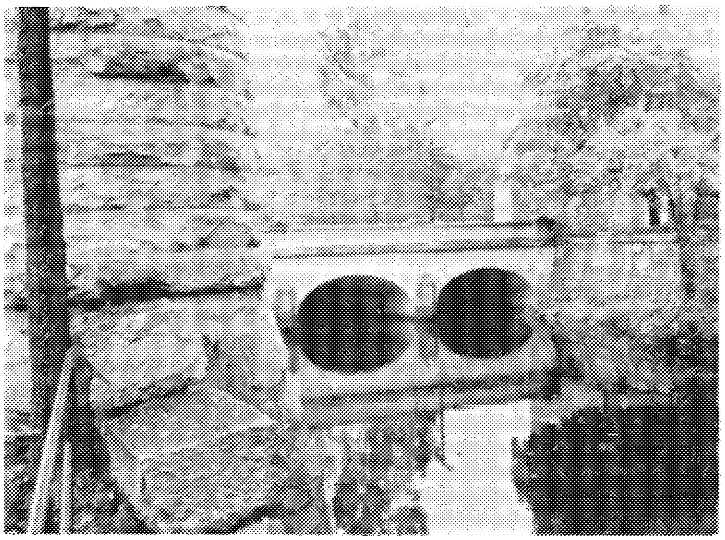


Osgood Street Bridge. Looking downstream -- Spicket River

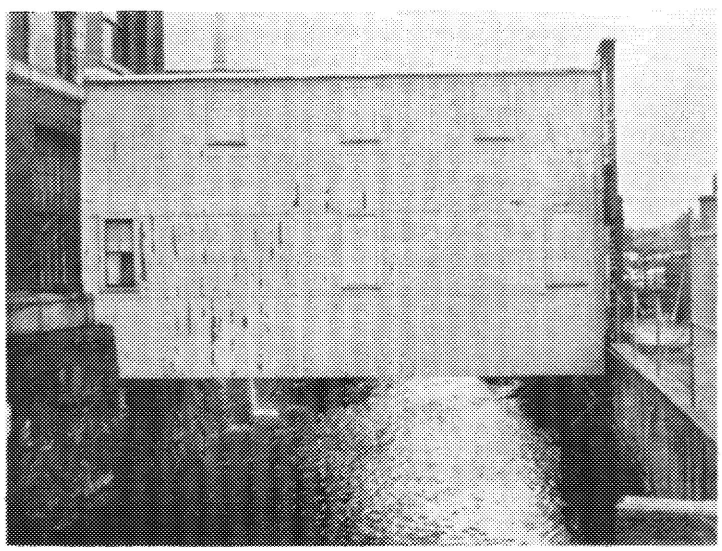


Building over Spicket River below Osgood Street

Figure 13

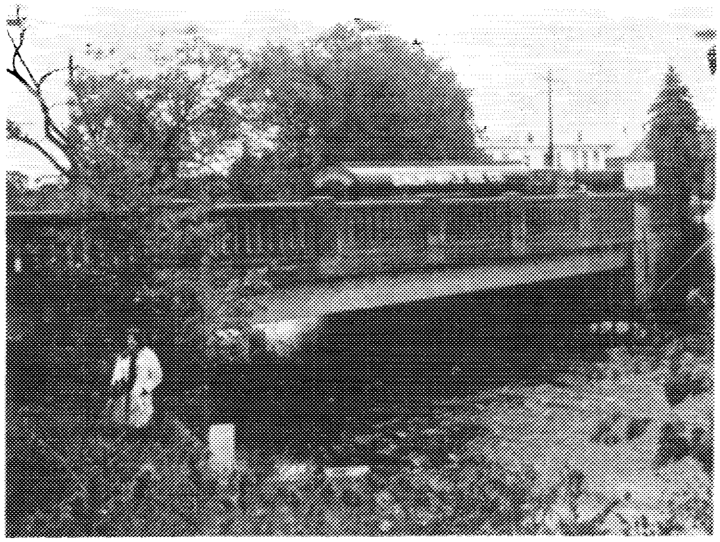


Broadway Bridge at Mile 30.95 -- Spicket River



Covered walkway over Spicket River at ITT Company on Broadway

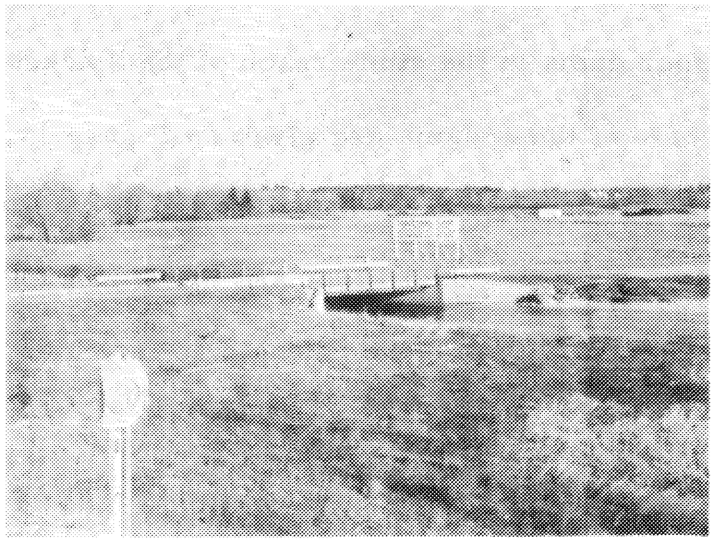
Figure 14



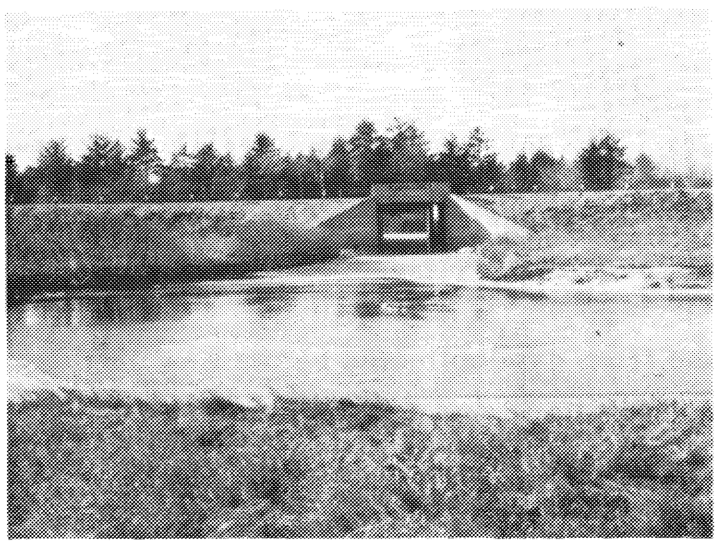
Hampshire Street Bridge
Looking Upstream - Spicket River

Bennington Street Bridge
Looking Downstream - Spicket River

Figure 15



Hampshire Road Bridge
At New Hampshire Stateline - Spicket River



I-93 Bridge Over Harris Brook
Relocated Spicket River in Foreground

Figure 16

Dams on the Spicket River

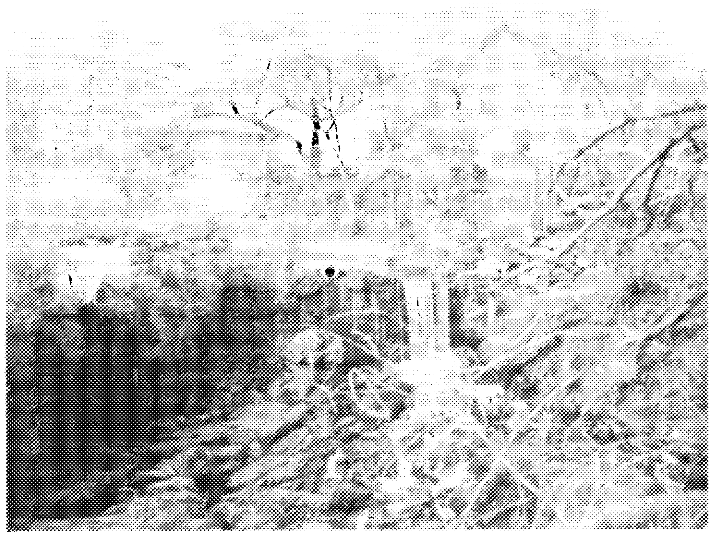
There are four dams in the study reach of the Spicket River. Views of some of these dams are given on Figure 17. Table 12 lists pertinent elevations for the dams and shows their relation to the Intermediate Regional Flood and the Standard Project Flood. A study of the profile and Table 12 indicates that these dams have little effect on flood flows.

Obstructions to Flood Flows

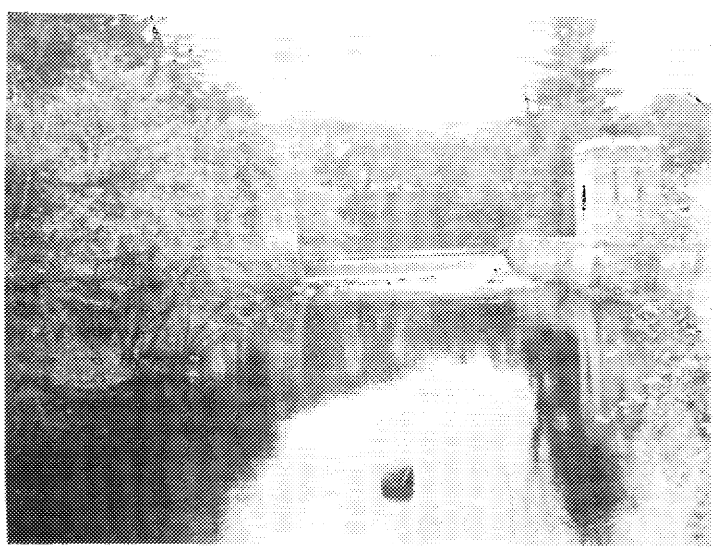
The effect of obstructions due to bridges or bridge approaches has been discussed in the previous paragraphs. Other significant obstructions to flows in the Spicket River reach included in this study have been discussed in previous paragraphs.

Flood Records

There are no USGS gaging stations in existence on the Spicket River. Information on floods was obtained from high water data collected and published for the March 1936 flood by the Massachusetts Geodetic Survey and from data collected by the New England Division, Corps of Engineers subsequent to the flood of October 1962. This information was supplemented by information obtained from local records as well as interviews with local residents for these and other floods.



Dam Below Lowell Street - Spicket River



Dam At Mile 31.02 Near Broadway - Spicket River

Figure 17

TABLE 12

DAMS ON THE SPICKET RIVER

River Mile	Identification	Crest Elev. ft. msl	IRF Crest ft. msl	SPF Crest ft. msl	Depth Over Dam	
					IRF ft.	SPF ft.
28.24	Dam	27.2	34.5	42.5	7.3	15.3
29.85	Malden Mills	54.8	58.5	60.1	3.7	5.3
31.02	Dam	61.2	65.0	67.0	3.8	5.8
31.28	Dam	101.3	107.0	109.0	5.7	7.7

Flood Occurrences

This investigation indicates that major floods have occurred with less frequency on the Spicket River than on the main stream of the Merrimack River. However, it can be expected that when a flood occurs on the Merrimack, at least minor flooding will take place along the Spicket River. There are no records of significant flood damage along the Spicket River.

Flooded Areas and Flood Profiles

Plates SP-1, SP-2, and M-2 show the approximate areas along the Spicket River that would be inundated by the Intermediate Regional Flood and the Standard Project Flood. The actual limits of the overflow areas on the ground may vary somewhat from those shown on the maps because the ten-foot contour interval and the scale of the map do not permit precise plotting of the flooded area boundaries.

Plate SP-3 shows high water marks for the flood of March 1936. Also shown are the profiles for the Intermediate Regional and Standard Project Floods which are discussed in the next section of this report.

Flood Descriptions

Descriptions of large floods on the Spicket River are included with the discussion of past floods on the Merrimack River.

FUTURE FLOODS

General

This section of the report discusses the Standard Project Flood and the Intermediate Regional Flood and some of the hazards of these great floods on the Merrimack River, the Shawsheen River and the Spicket River in the study area. A flood comparable to the Standard Project Flood can reasonably be expected. The Intermediate Regional Flood may be expected to occur more frequently but will not be as high as the Standard Project Flood.

Large floods have been experienced in the past on streams in the general geographical and physiographical region of Lawrence. Heavy storms similar to those causing these floods could occur over the watersheds of the Merrimack River. In this event, floods would result on this stream comparable in size with those experienced on neighboring streams. It is therefore desirable, in connection with any determination of future floods which may occur on the Merrimack, Shawsheen and Spicket Rivers, to consider storms and floods that have occurred in the region or watersheds whose topography, watershed cover, and physical characteristics are similar to those of the three rivers.

Determination of Intermediate Regional Floods

The Intermediate Regional Flood is defined as a flood having an average frequency of occurrence in the order of once in 100 years at a designated location, although the flood may occur in any year. For this reason, the Intermediate Regional Flood is better described as a flood with a one percent chance of occurring any year. Some probability estimates are based on statistical analyses of stream flow records available for the watersheds under study, but limitations in such records usually require analyses of rainfall and runoff characteristics in the "general region" of the areas under study. The Intermediate Regional Flood represents a major flood, although it is much less than the Standard Project Flood.

Determination of Standard Project Floods

The largest flood that is likely to occur on a specific stream has been experienced only in rare instances. It is an accepted fact that, as severe as the maximum known flood may have been, sooner or later a larger flood can and probably will occur. The Corps of Engineers, in cooperation with the National Weather Service, has made broad and comprehensive studies and investigations based on the vast records of experienced storms and floods and has evolved generalized procedures for estimating the flood potentials of streams. These procedures have been used in determining the Standard Project Flood. It is defined as the largest flood that can be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical region involved.

Frequency

It is not practical to assign a frequency to the Standard Project Flood. The occurrence of such a flood would be a rare event.

Possible Larger Floods

Floods larger than the Standard Project Flood are possible; however, the combination of factors that would be necessary to produce such floods would seldom occur. The consideration of floods of this magnitude is of greater importance in some problems than in others but should not be overlooked in the study of any problem.

Hazards of Great Floods

The amount and extent of damage caused by any flood depends in general upon how much area is flooded, the height of flooding, the velocity of flow, the rate of rise, and the duration of flooding.

Areas Flooded and Heights of Flooding

The areas along the Merrimack River, the Shawsheen River and the Spicket River which would be flooded by the Standard Project Flood and the Intermediate Regional Flood, are shown on Plates M-1 through M-4, SH-1, SH-2, SP-1 and SP-2. Depths of flow can be estimated from the crest profiles which are shown on Plates M-5, M-6, SH-3 and SP-3.

The profiles for the streams were computed by using stream characteristics for selected reaches as determined from observed flood profiles, topographic maps and valley cross sections. The elevations shown on Plates M-5, M-6, SH-3 and SP-3 and the overflow areas shown on Plates M-1 through M-4, SH-1, SH-2, SP-1 and SP-2 have been determined with an accuracy consistent with the purposes of this study and the accuracy of these data.

The profiles of the Standard Project Flood and the Intermediate Regional Flood depend in part upon the degree of destruction or clogging of various bridges during the flood. Because it is impossible to forecast these events, it was assumed that all bridge structures would stand and that no clogging would occur.

The Standard Project Flood profile for the Merrimack River in the reach studied is 3 to 6 feet below the March 1936 flood. The maximum difference occurs at the upstream limit of the study area and is the result of narrowing of the valley. The Standard Project

Flood profile for the Shawsheen River is 3.0 to 3.5 feet below the March 1936 flood in the reach from its mouth at the Merrimack River to the tailwater of the Stevens Dam at Mile 31.94 and is caused by backwater from the Merrimack River. From the headwater of the Stevens Dam to the dam at Mile 32.54, the elevation of the profile is 4.0 feet above the March 1936 flood. From the upstream side of the dam to the Central Street Bridge, the profile is 5.0 feet to 2.0 feet above the March 1936 flood. Upstream from the Central Street Bridge to the upper limit of the study at the Andover-Tewksbury townline, the elevation of the Standard Project Flood is approximately the same as the March 1936 flood. The Standard Project Flood profile for the Spicket River is 2.5 feet below the March 1936 flood at its mouth at the Merrimack River to zero at the East Haverhill Street Bridge at Mile 28.7. This is caused by backwater from the Merrimack River. From East Haverhill Street to the upper limit of the study, the Standard Project Flood profile rises to 2.0 feet above the March 1936 flood.

The Intermediate Regional Flood profile for the Merrimack River is 10.0 feet below the March 1936 flood at the lower end of the study area to 15.5 feet below at the downstream side of the Essex Company Dam. The elevation of the Intermediate Regional Flood profile at the upstream side of the dam is 6.0 feet below the March 1936 flood to 12.0 feet below at the upper limit of the study. The Intermediate Regional Flood profile for the Shawsheen River is 11.0 feet to 8.0 feet below the March 1936 flood in the reach from the mouth at the Merrimack River to the Stevens Dam. From the head-water of the Stevens Dam to the dam at Mile 32.54, the elevation of the profile is 3.0 feet above the March 1936 flood. From the upstream side of the dam to the Central Street Bridge, the profile is 4.0 feet to 1.0 foot above the March 1936 flood. Upstream from the Central StreetBridge to the upper limit of the study area, the Intermediate Regional Flood is one foot below the March 1936 flood. The Intermediate Regional Flood profile for the Spicket River is 10.75 feet below the March 1936 flood at its mouth at the Merrimack River to zero at Mile 28.8 just above the Jackson Street Bridge, or the same elevation as the March 1936 flood. From this point to the upper limit of the study area, the Intermediate Regional Flood profile is approximately the same as the March 1936 flood profile.

Figures 20 through 25 show the heights that would be reached by the Standard Project Flood and the Intermediate Regional Flood on facilities presently existing on the flood plains in the study area.

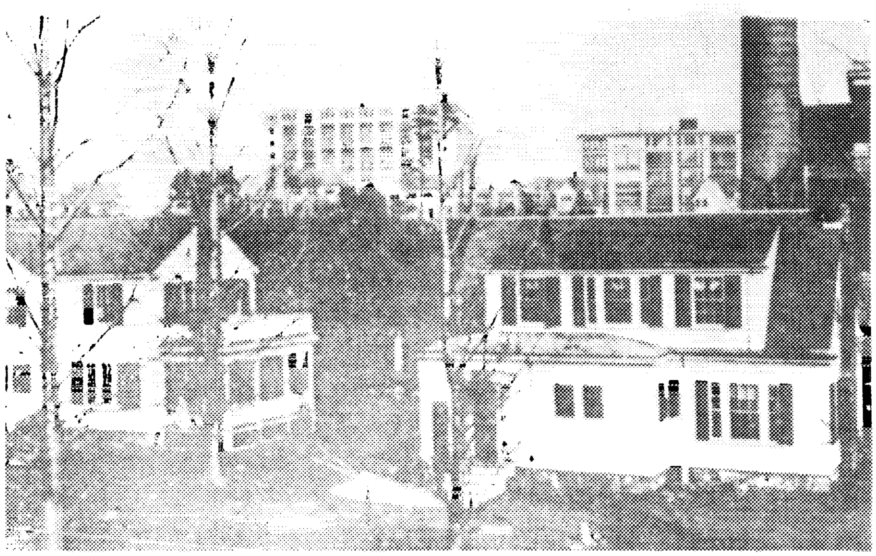
The Standard Project Flood and the Intermediate Regional Flood would reach much higher elevations on the Merrimack River if it were not for the four reservoirs upstream. Flood Heights on the lower reaches of the Shawsheen and Spicket Rivers are also lowered because of the reduced backwater heights from the Merrimack River.

North Andover, Mass., March 21, 1936, 1:30 p.m. Backwater on the Shawsheen River 700 feet from the Merrimack River. View from boat above the right-of-way of the B&M RR, looking southerly along Beverly Street. H.W. elevation 44.0 feet.

Photograph taken March 24, 1936, of the same view pictured above. Note the boat at the foot of tree used during the flood.

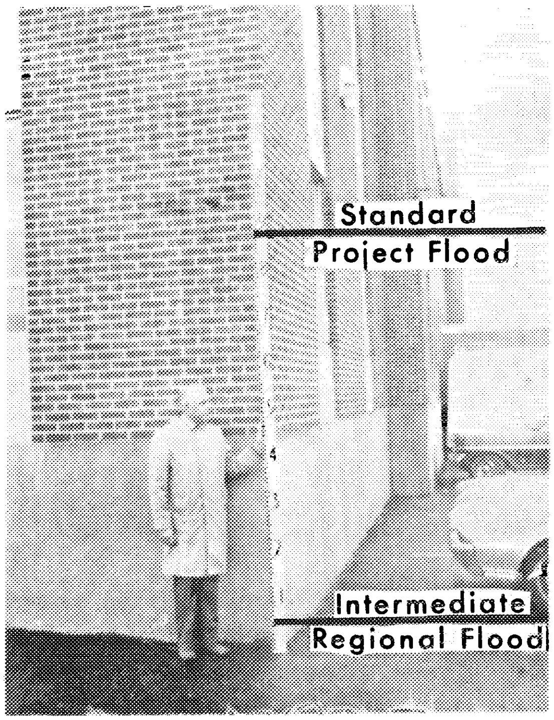
Figure 18

Shawsheen Village in Andover, Mass., March 21, 1936, 1:00 p.m. View just north of the Mall, from rear of Shawsheen Manor of the dwellings on Riverina Road. The Shawsheen River lies between the houses and the high land in the background. H. W. elevation 44.4 feet.

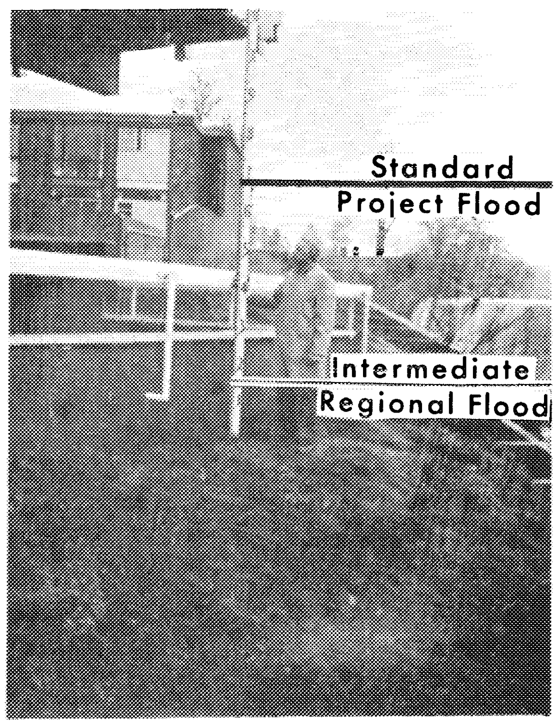


Photograph taken March 24, 1936, of the same river pictured above. The average elevation of Riverina Road at this point is 35.8 feet.

Figure 19

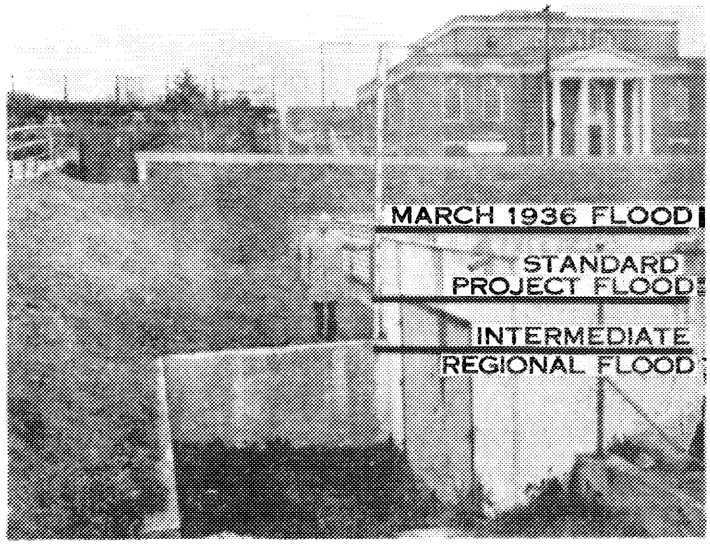


Lawrence
Community
Services
Building -
Merrimack River



Lamplighter
Rest
Home -
Merrimack River

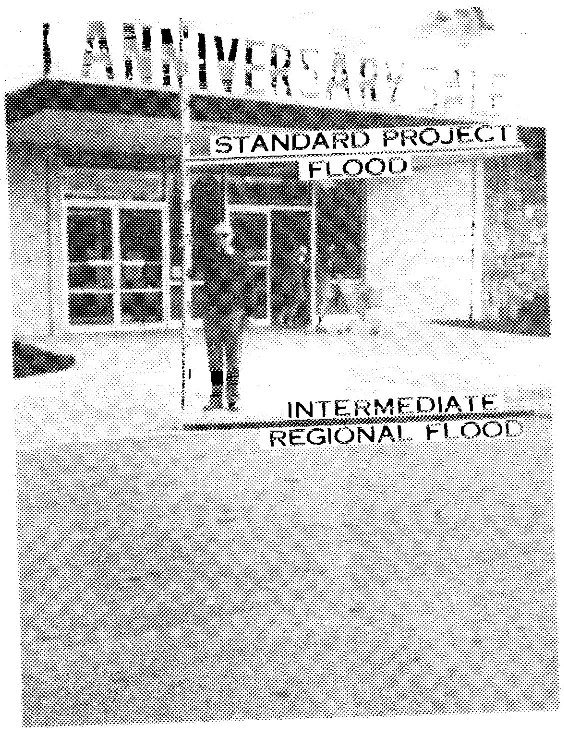
Figure 20



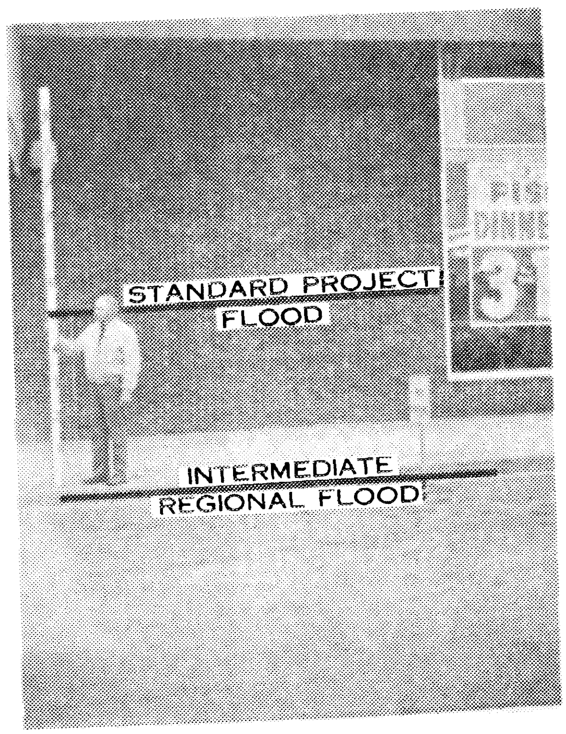
Lawrence Water Filtration Plant. Photo shows March 1936 flood high water mark and floodheights if the dike had not been constructed - Merrimack River

Pacific Mills - Merrimack River

Figure 21

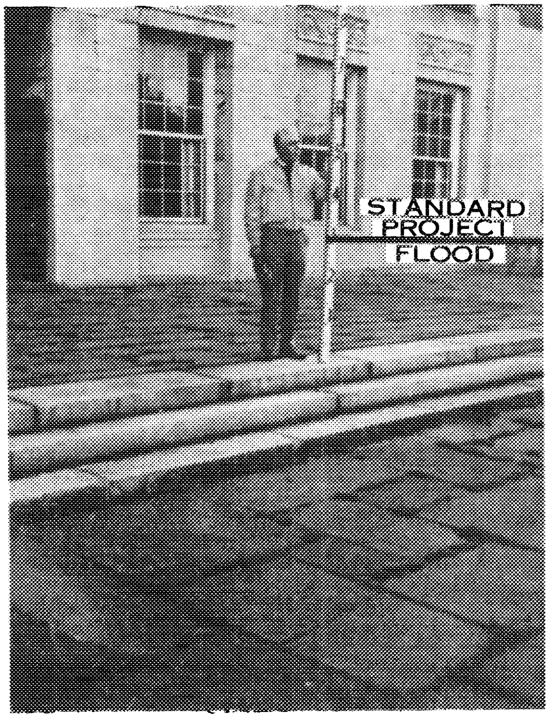


W. T. Grant Co. at
North Andover
Shopping Mall -
Shawsheen River

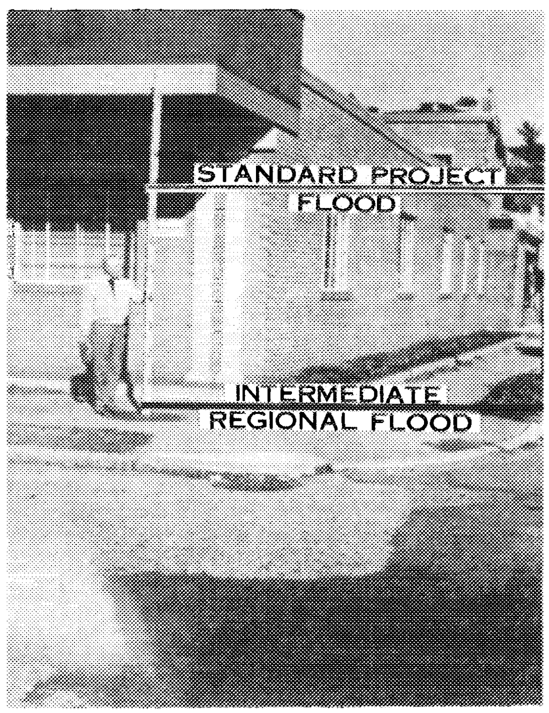


De Moulas
Supermarket
at Shawsheen
Shopping Plaza -
Shawsheen River

Figure 22



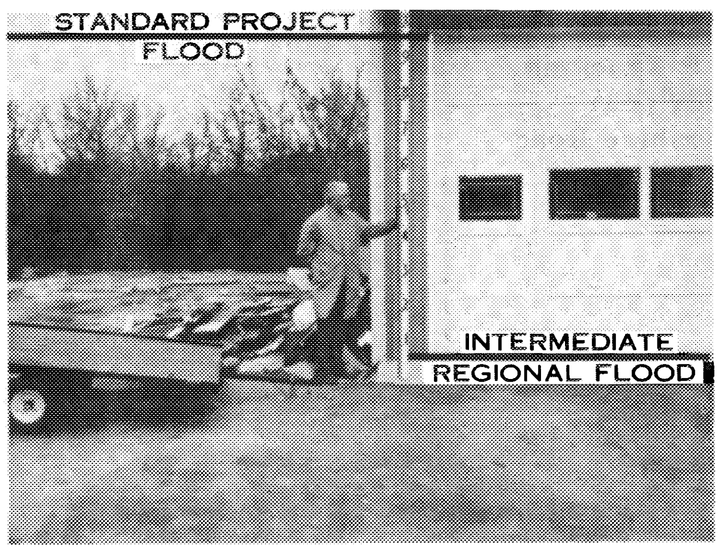
Sacred Heart School (Formerly American Woolen Company Administration Building.) - Shawsheen Village - Shawsheen River



Office Building
No. 10 Haverhill Street
Shawsheen Village -
Shawsheen River

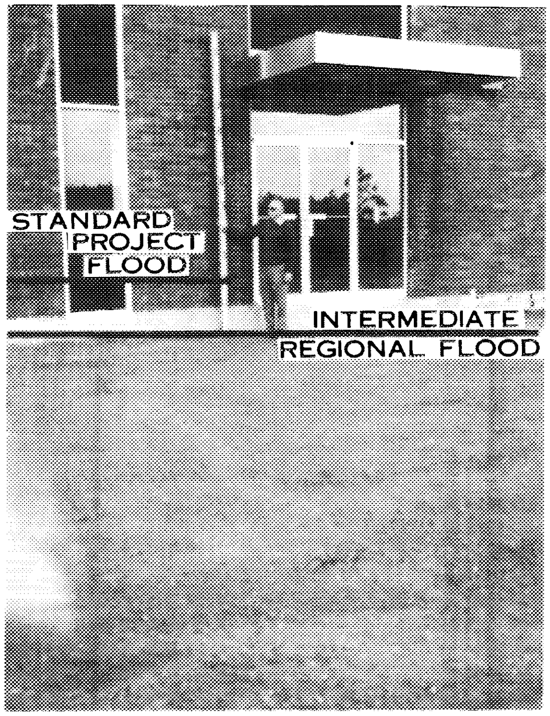
Figure 23

Shell Gas Station on Mass. Ave. -
Shawsheen River



Barron Oil Company, Mass. Ave. -
Shawsheen River

Figure 24



New Building,
Hampshire Road -
Spicket River

V & P Trucking
Center near
Hampshire Road -
Spicket River

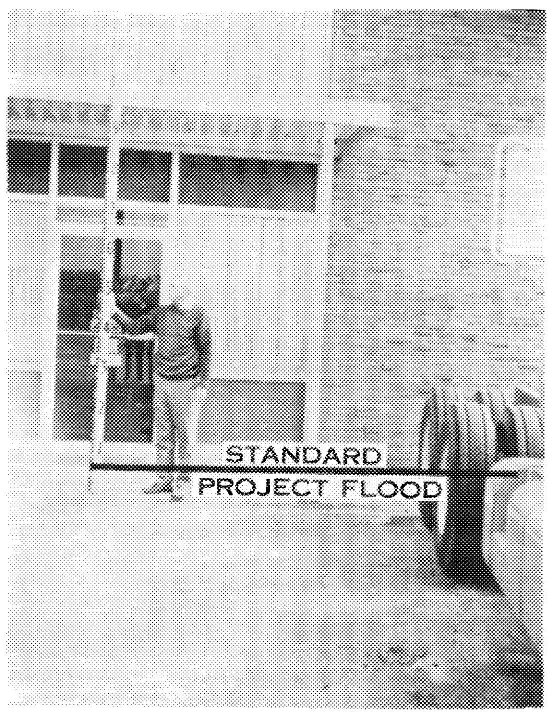


Figure 25

GLOSSARY

Backwater. The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water.

Normally a "flood" is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased streamflow, and other problems.

Flood Crest. The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Plain. The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water that have been or may be covered by floodwater.

Flood Profile. A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage. The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Hurricane. An intense cyclonic windstorm of tropical origin in which winds tend to spiral inward in a counterclockwise direction toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 miles per hour (65 knots) for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 75 miles per hour.

Hydrograph. A graph showing flow values against time at a given point, usually measured in cubic feet per second. The area under the curve indicates total volume of flow.

Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

Left Bank. The bank on the left side of a river, stream, or watercourse, looking downstream.

Right Bank. The bank on the right side of a river, stream, or watercourse, looking downstream.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40-60 percent of the Probable Maximum Floods for the same basins. As used by the Corps of Engineers, Standard Project Floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Underclearance Elevation. The elevation at the top of the opening of a culvert, or other structure through which water may flow along a watercourse.

AUTHORITY, ACKNOWLEDGEMENTS AND INTERPRETATION OF DATA

This report has been prepared in accordance with the authority granted by Section 206 of the Flood Control Act of 1960 (P. L. 86-645), as amended.

Assistance and cooperation of the National Weather Service, U.S. Geological Survey, the city of Lawrence, the towns of Andover, North Andover and Methuen, Massachusetts Department of Public Works and private citizens in supplying useful data are appreciated.

This report presents the local flood situation for the city of Lawrence and the towns of Andover, North Andover and Methuen. The New England Division, Corps of Engineers will provide interpretation and limited technical assistance in the application of data presented therein.

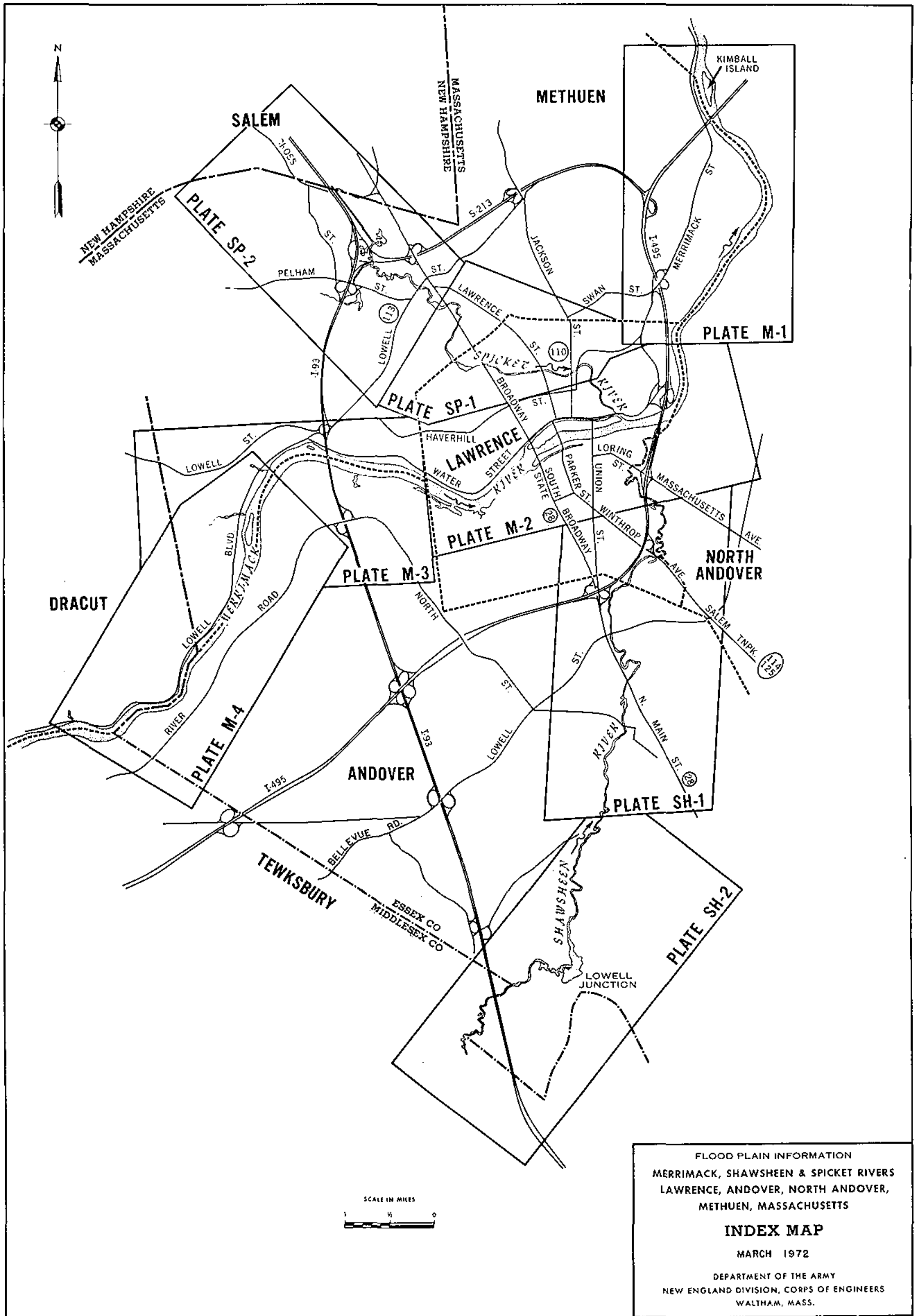

N
SALEM
METHUEN
KIMBALL ISLAND
MASSACHUSETTS
NEW HAMPSHIRE
NEW HAMPSHIRE
MASSACHUSETTS
PLATE SP-2
PLATE SP-1
PLATE M-1
PLATE M-2
PLATE M-3
PLATE M-4
PLATE SH-1
PLATE SH-2
LAWRENCE
DRACUT
NORTH ANDOVER
ANDOVER
TEWKSBURY
ESSEX CO
MIDDLESEX CO
LOWELL JUNCTION
SPICKET RIVER
MERRIMACK RIVER
SHAWSHEEN RIVER
I-93
I-495
S-213
PELHAM ST.
LOWELL ST.
LAWRENCE ST.
JACKSON ST.
SWAN ST.
MERRIMACK ST.
BROADWAY
HAVERHILL ST.
WATER STREET
SOUTH BROADWAY
STATE
PARKER ST.
UNION ST.
LORING ST.
WINTHROP AVE.
MASSACHUSETTS AVE.
SALEM TNPK.
N. MAIN ST.
NORTH ST.
LOWELL BLVD
RIVER ROAD
BELLEVUE RD.
SCALE IN MILES
FLOOD PLAIN INFORMATION
MERRIMACK, SHAWSHEEN & SPICKET RIVERS
LAWRENCE, ANDOVER, NORTH ANDOVER,
METHUEN, MASSACHUSETTS
INDEX MAP
MARCH 1972
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO.5

CORPS OF ENGINEERS

U.S. ARMY

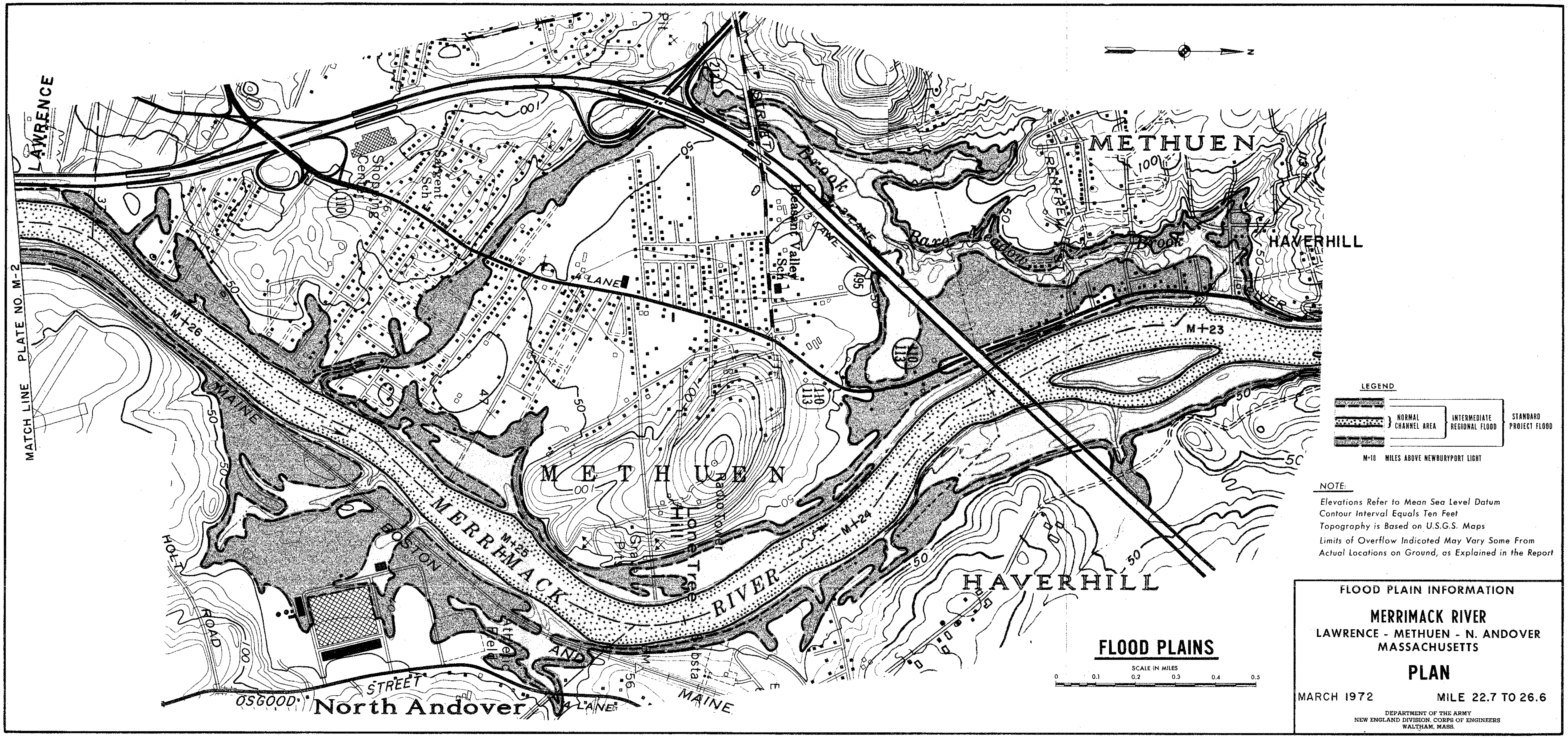
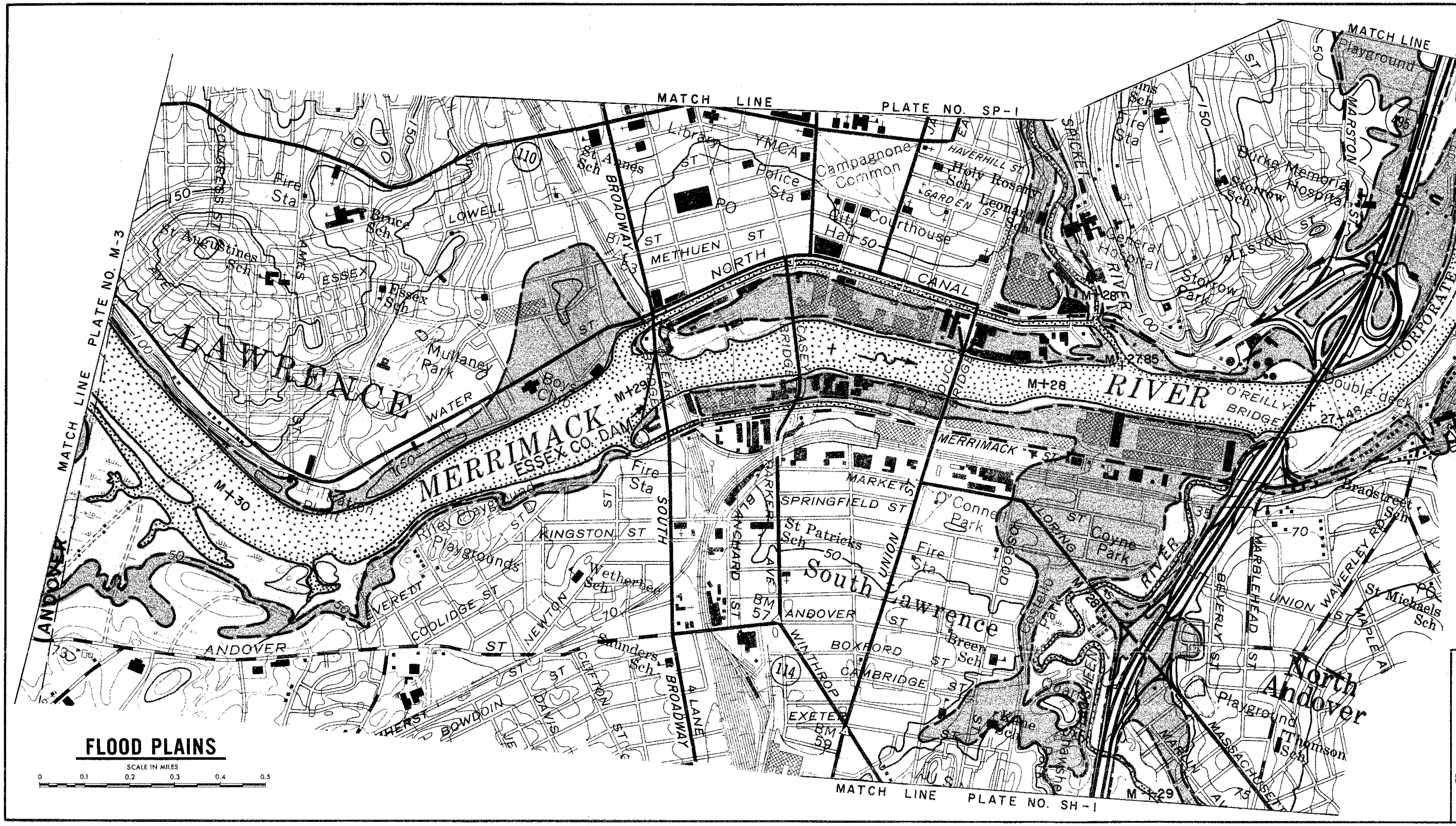


PLATE NO. M-1



LEGEND

NORMAL CHANNEL AREA | INTERMEDIATE REGIONAL FLOOD | STANDARD PROJECT FLOOD

M+10 MILES ABOVE NEWBURYPORT LIGHT

NOTE:

Elevations Refer to Mean Sea Level Datum
Contour Interval Equals Ten Feet
Topography is Based on U.S.G.S. Maps
Limits of Overflow Indicated May Vary Some From Actual Locations on Ground, as Explained in the Report

FLOOD PLAIN INFORMATION

MERRIMACK RIVER

LAWRENCE - METHUEN - N. ANDOVER
MASSACHUSETTS

PLAN

MARCH 1972 MILE 26.6 TO 30.4

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

NOTE:

Elevations Refer to Mean Sea Level Datum
Contour Interval Equals Ten Feet
Topography is Based on U.S.G.S. Maps
Limits of Overflow Indicated May Vary Some From Actual Locations on Ground, as Explained in the Report

FLOOD PLAINS

SCALE IN MILES
0 0.1 0.2 0.3 0.4 0.5

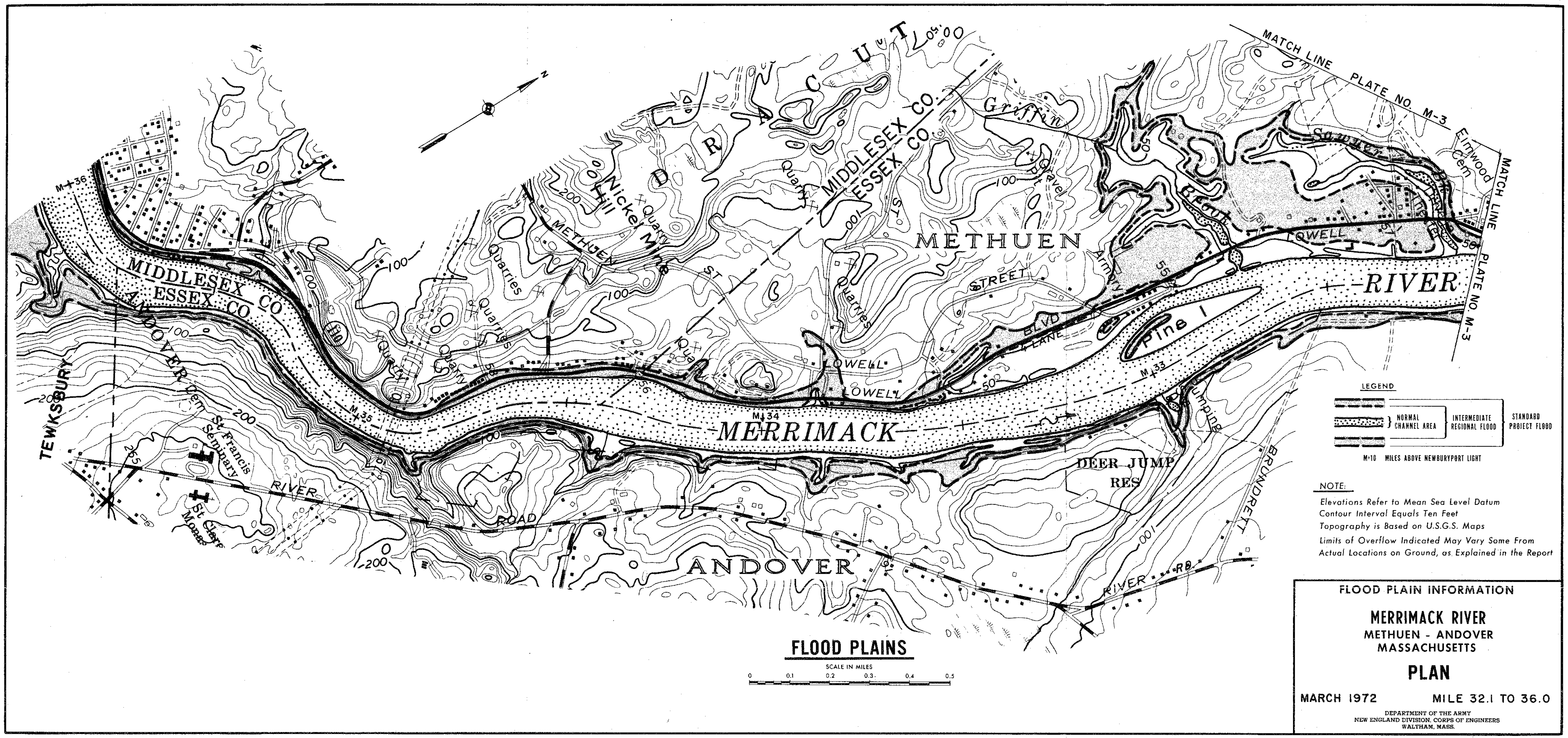
FLOOD PLAIN INFORMATION

MERRIMACK RIVER
ANDOVER - METHUEN - LAWRENCE
MASSACHUSETTS

PLAN

MARCH 1972 MILE 30.4 TO 32.1

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



LEGEND

NORMAL CHANNEL AREA	INTERMEDIATE REGIONAL FLOOD	STANDARD PROJECT FLOOD

M+10 MILES ABOVE NEWBURYPORT LIGHT

NOTE:

Elevations Refer to Mean Sea Level Datum
Contour Interval Equals Ten Feet
Topography is Based on U.S.G.S. Maps
Limits of Overflow Indicated May Vary Some From Actual Locations on Ground, as Explained in the Report

FLOOD PLAIN INFORMATION

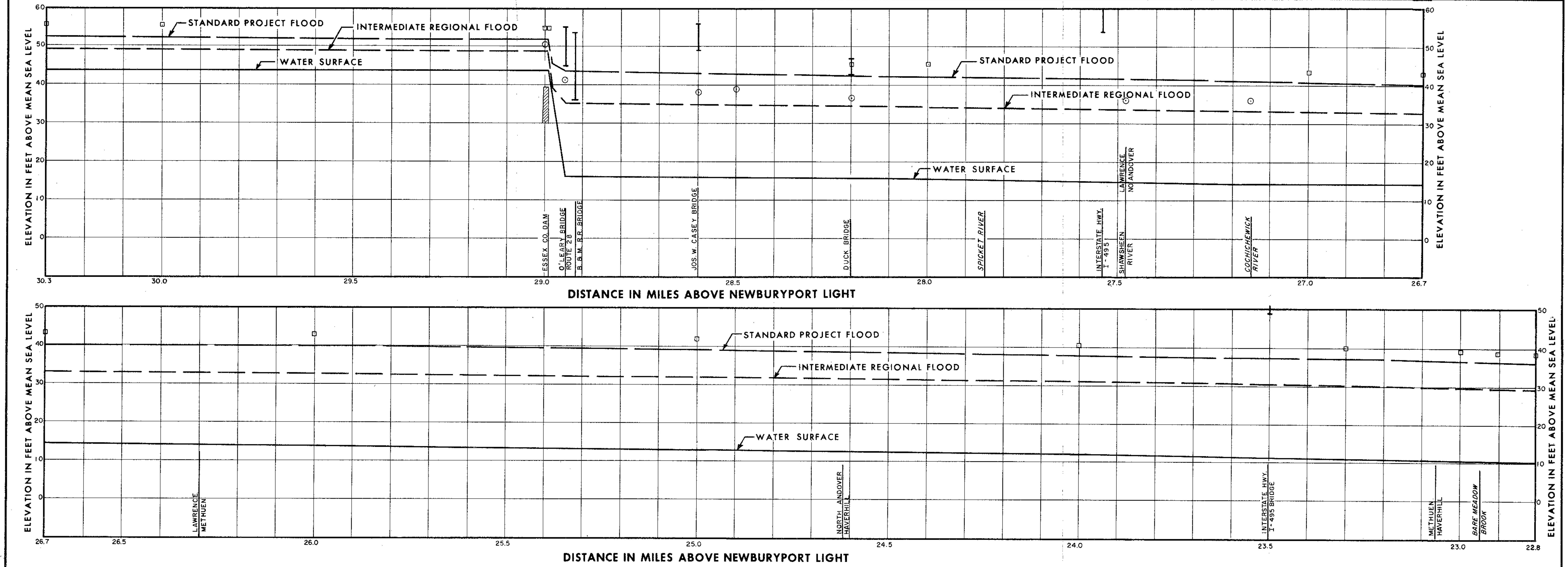
MERRIMACK RIVER
METHUEN - ANDOVER
MASSACHUSETTS

PLAN

MARCH 1972 MILE 32.1 TO 36.0

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

CORPS OF ENGINEERS U. S. ARMY



LEGEND

- MARCH 21, 1936 HIGH WATER ELEVATION
- SEPTEMBER 1938 HIGH WATER ELEVATION
- BRIDGE
- DAM
- LOW STEEL OF BRIDGE

NOTE
FOR PLANS, SEE PLATE NOS. M-1 AND M-2

FLOOD PLAIN INFORMATION

MERRIMACK RIVER

ANDOVER, LAWRENCE, METHUEN, N. ANDOVER
MASSACHUSETTS

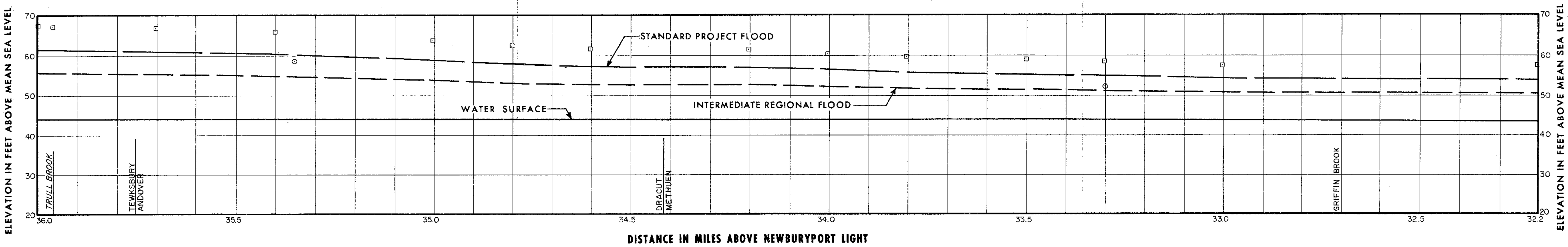
FLOOD PROFILES

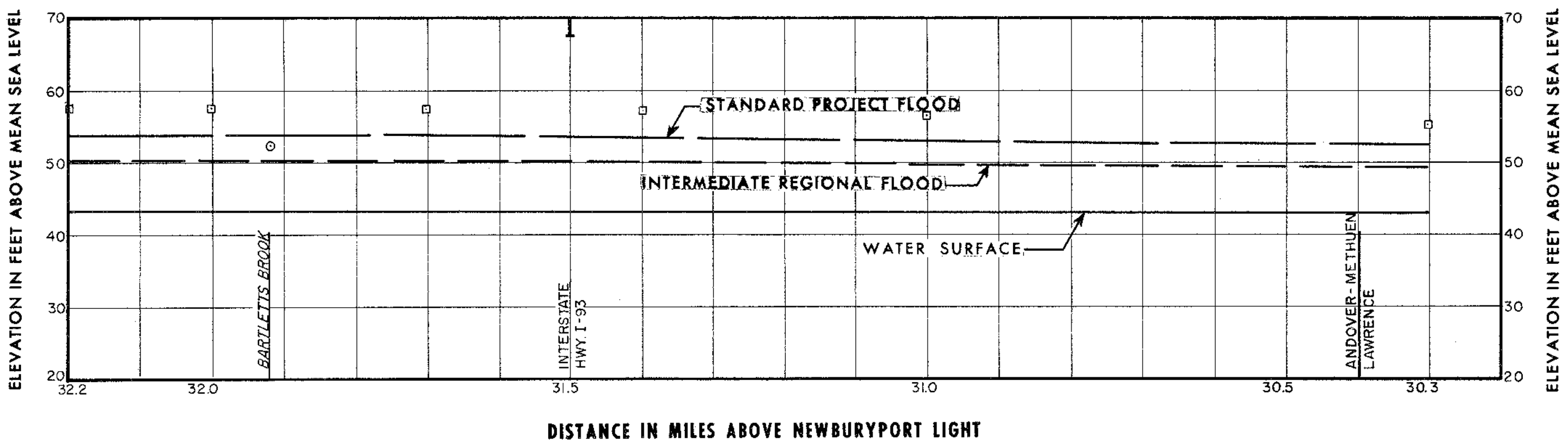
MILE 22.8 – 30.3

MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. M-5





NOTE

FOR PLANS, SEE PLATE NOS. M-2, M-3 AND M-4

LEGEND

- ⊡ MARCH 21 1936 HIGH WATER ELEVATION
- ⊙ SEPTEMBER 1938 HIGH WATER ELEVATION
- I LOW STEEL OF BRIDGE

FLOOD PLAIN INFORMATION

MERRIMACK RIVER

ANDOVER, LAWRENCE, METHUEN, MASSACHUSETTS

FLOOD PROFILES

MILES 30.3 36.0

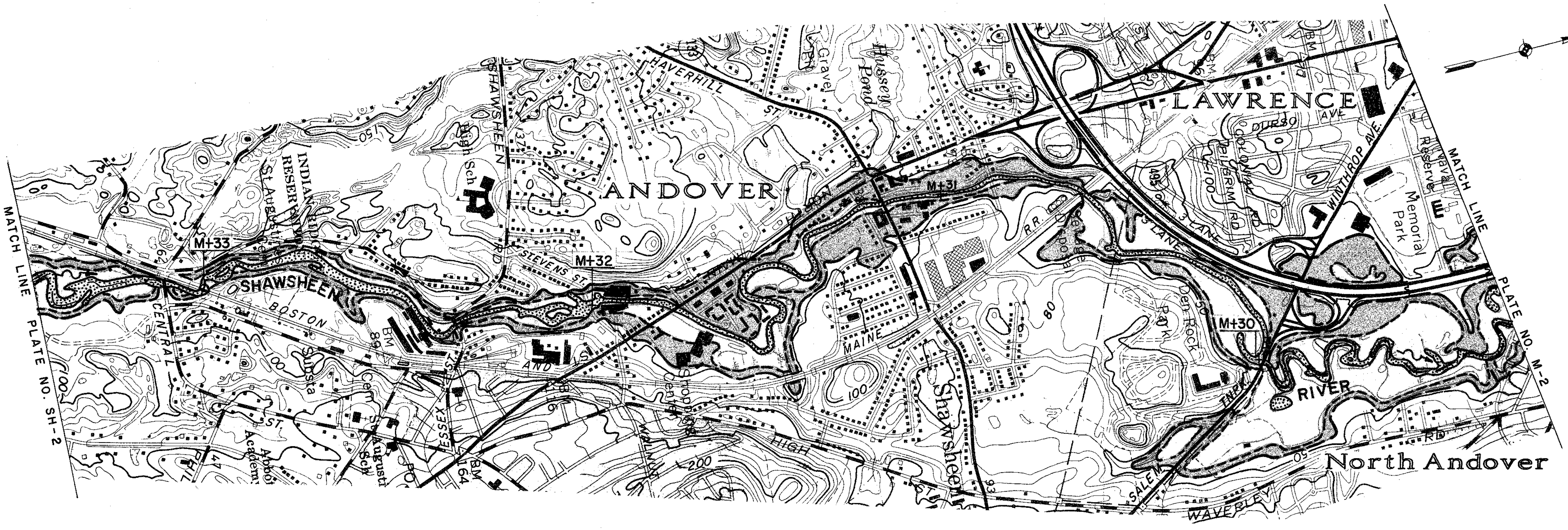
MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. M-6

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

NORMAL CHANNEL AREA | INTERMEDIATE REGIONAL FLOOD | STANDARD PROJECT FLOOD

M+5 MILES ABOVE NEWBURYPORT LIGHT

NOTE:

Elevations Refer to Mean Sea Level Datum
Contour Interval Equals Ten Feet
Topography is Based on U.S.G.S. Maps
Limits of Overflow Indicated May Vary Some From Actual Locations on Ground, as Explained in the Report

FLOOD PLAINS

SCALE IN MILES

0 0.1 0.2 0.3 0.4 0.5

NOTE:
FOR PLAN OF SHAWSHEEN RIVER FROM MOUTH TO MILE 29.1 SEE PLATE M-2

FLOOD PLAIN INFORMATION

SHAWSHEEN RIVER

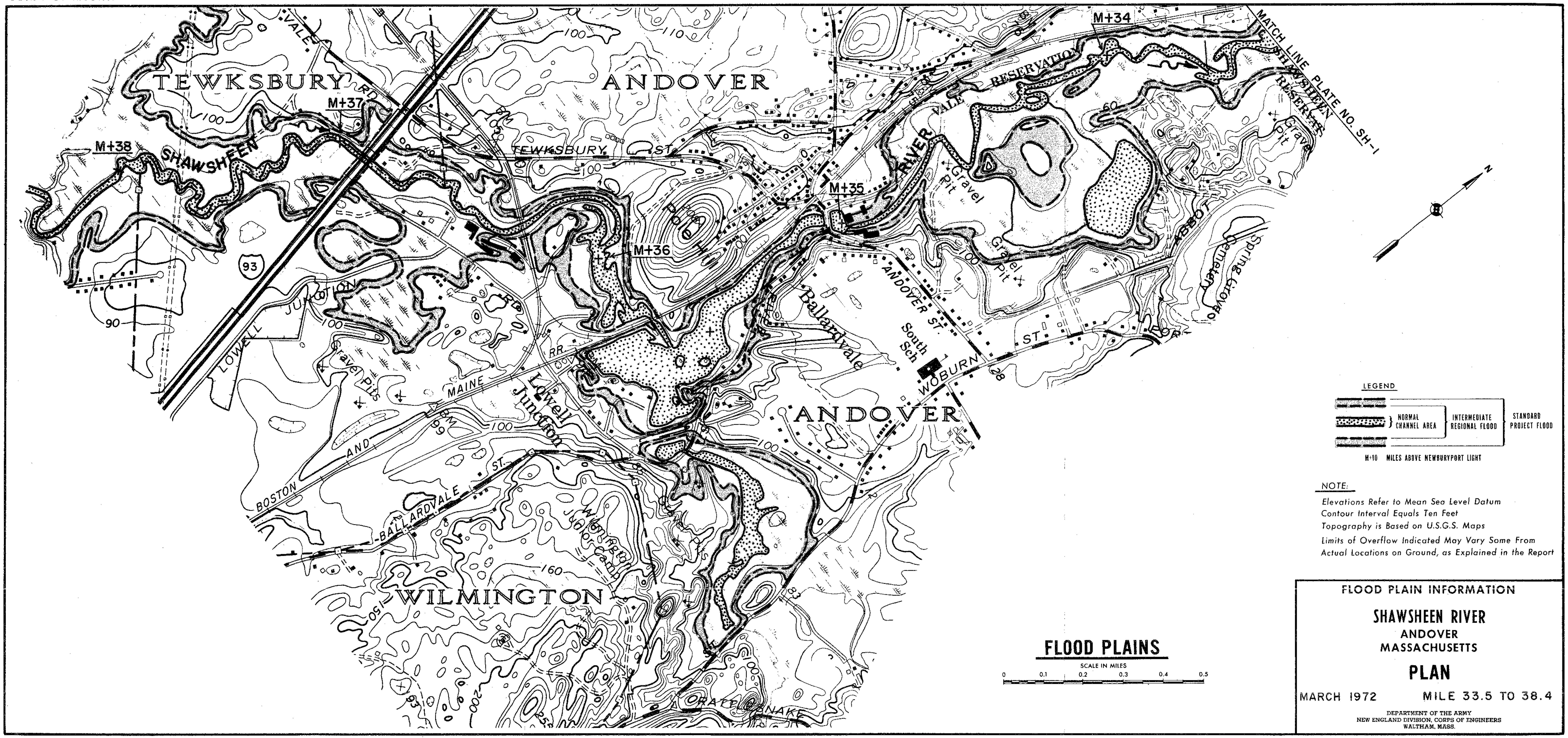
ANDOVER - LAWRENCE - N. ANDOVER
MASSACHUSETTS

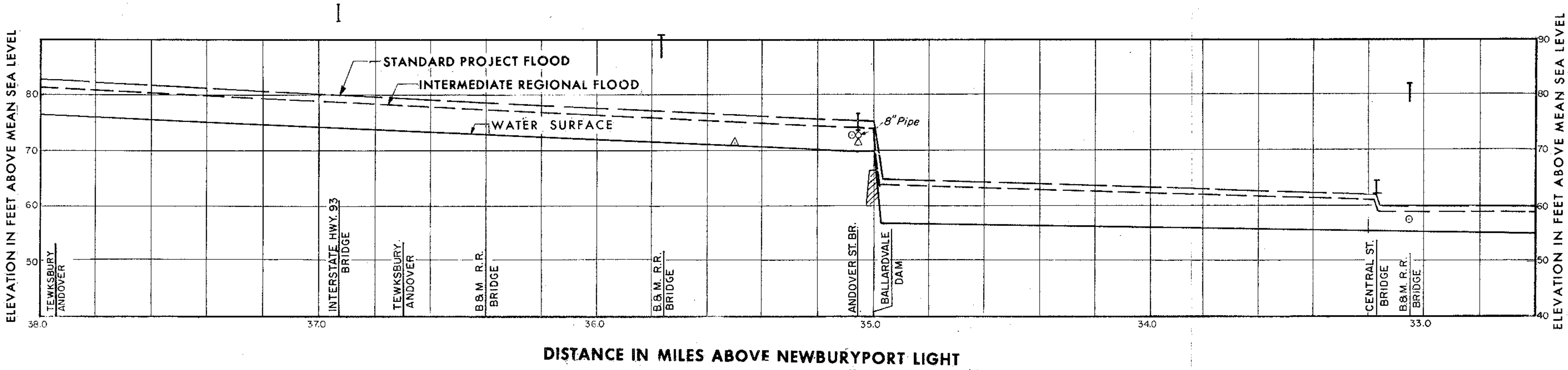
PLAN

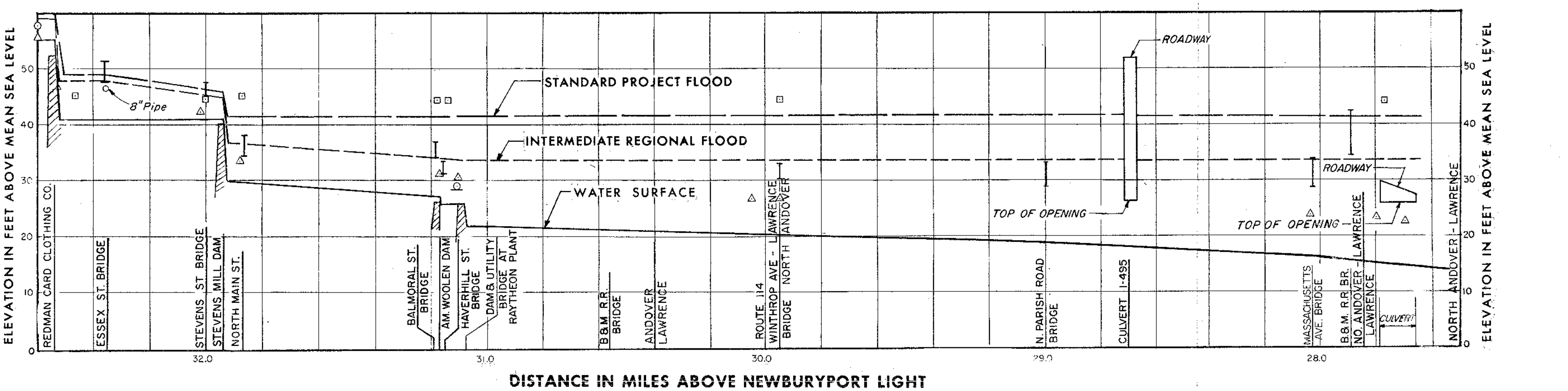
MARCH 1972 MILE 29.1 TO 33.5

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE NO. SH-1


TEWKSBURY
ANDOVER
ANDOVER
WILMINGTON
SHAWSHEEN
RIVER
M+38
M+37
M+36
M+35
M+34
93
LOWELL JUNCTION RD
TEWKSBURY ST
BOSTON AND MAINE RR
BALLARDVALE ST
Lowell Junction
Ballardvale
South Sch
ANDOVER ST
WOBURN ST
Gravel Pits
Gravel Pit
Gravel Pit
RESERVATION
Spring Grove
MATCH LINE PLATE NO. SH-1
LEGEND
NORMAL CHANNEL AREA
INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD
M+10 MILES ABOVE NEWBURYPORT LIGHT
NOTE:
Elevations Refer to Mean Sea Level Datum
Contour Interval Equals Ten Feet
Topography is Based on U.S.G.S. Maps
Limits of Overflow Indicated May Vary Some From Actual Locations on Ground, as Explained in the Report
FLOOD PLAINS
SCALE IN MILES
0 0.1 0.2 0.3 0.4 0.5
FLOOD PLAIN INFORMATION
SHAWSHEEN RIVER
ANDOVER
MASSACHUSETTS
PLAN
MARCH 1972
MILE 33.5 TO 38.4
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.





NOTE:

FOR PLANS SEE PLATES NO. SH.-1, SH.-2, & M-2

LEGEND

- ▫ MARCH 21, 1936 HIGH WATER ELEVATION
- ⊙ MARCH 13, 1936 HIGH WATER ELEVATION
- △ OCTOBER 1962
- I BRIDGE
- DAM
- ▯ CULVERT

FLOOD PLAIN INFORMATION

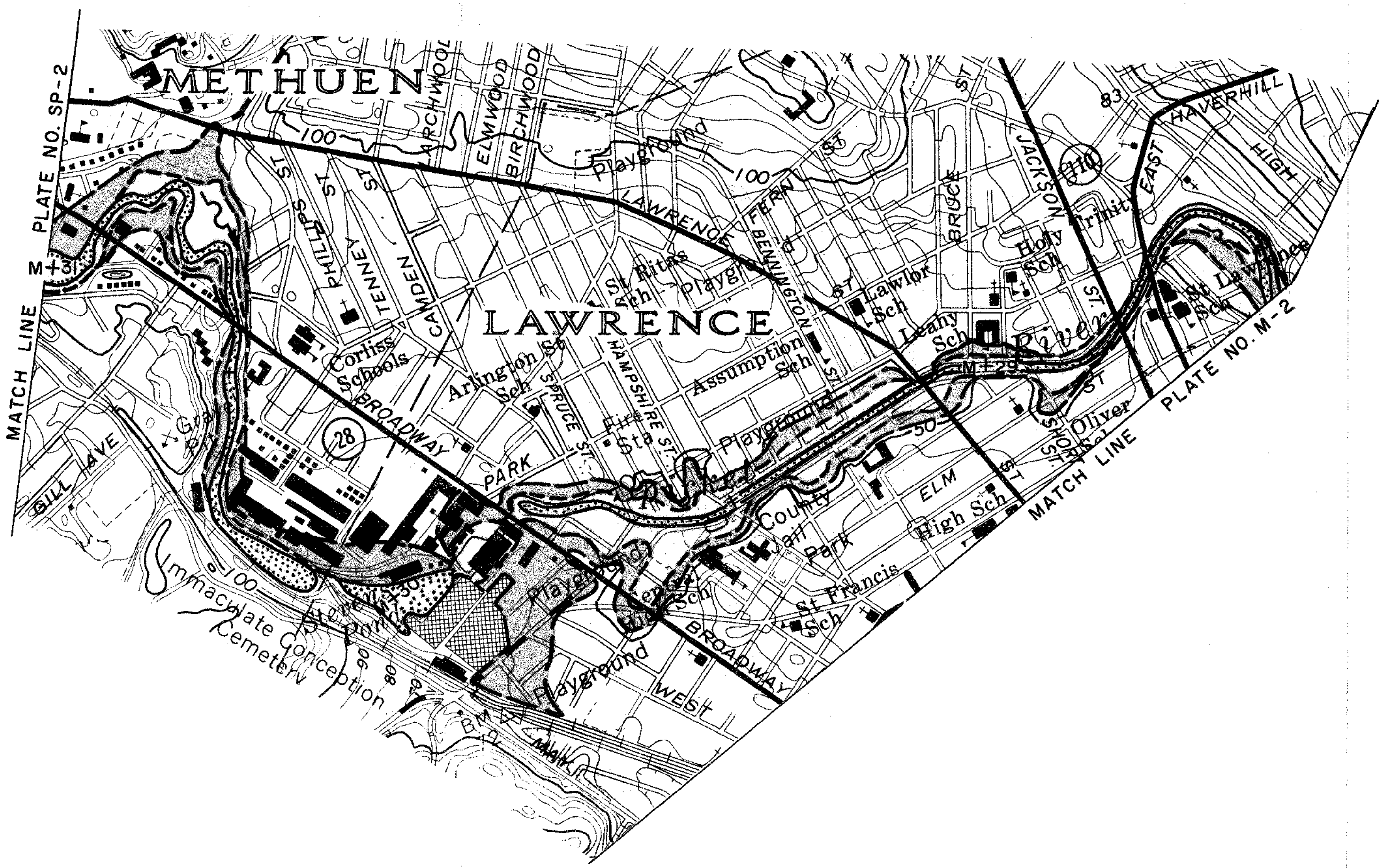
SHAWSHEEN RIVER

ANDOVER, LAWRENCE, N. ANDOVER
MASSACHUSETTS

FLOOD PROFILES

MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



FLOOD PLAINS

SCALE IN MILES

0 0.1 0.2 0.3 0.4 0.5

NOTE:
FOR PLAN OF SPICKET RIVER FROM MOUTH TO MILE 28.4 SEE PLATE M-2

LEGEND

NORMAL CHANNEL AREA
INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD

M+19 MILES ABOVE NEWBURYPORT LIGHT

NOTE:
Elevations Refer to Mean Sea Level Datum
Contour Interval Equals Ten Feet
Topography is Based on U.S.G.S. Maps
Limits of Overflow Indicated May Vary Some From Actual Locations on Ground, as Explained in the Report

FLOOD PLAIN INFORMATION

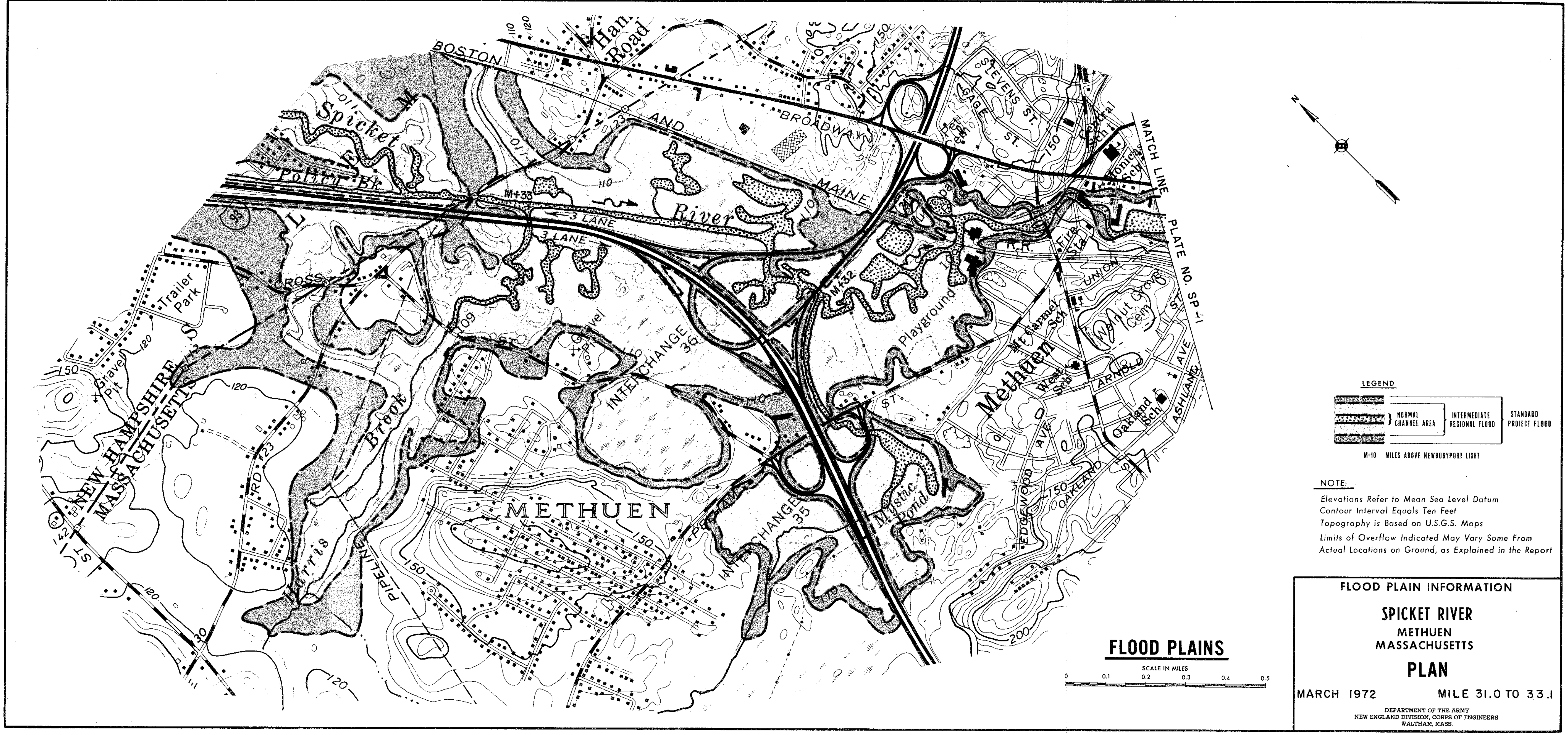
SPICKET RIVER

METHUEN - LAWRENCE
MASSACHUSETTS

PLAN

MARCH 1972 MILE 28.4 TO 31.0

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



FLOOD PLAIN INFORMATION

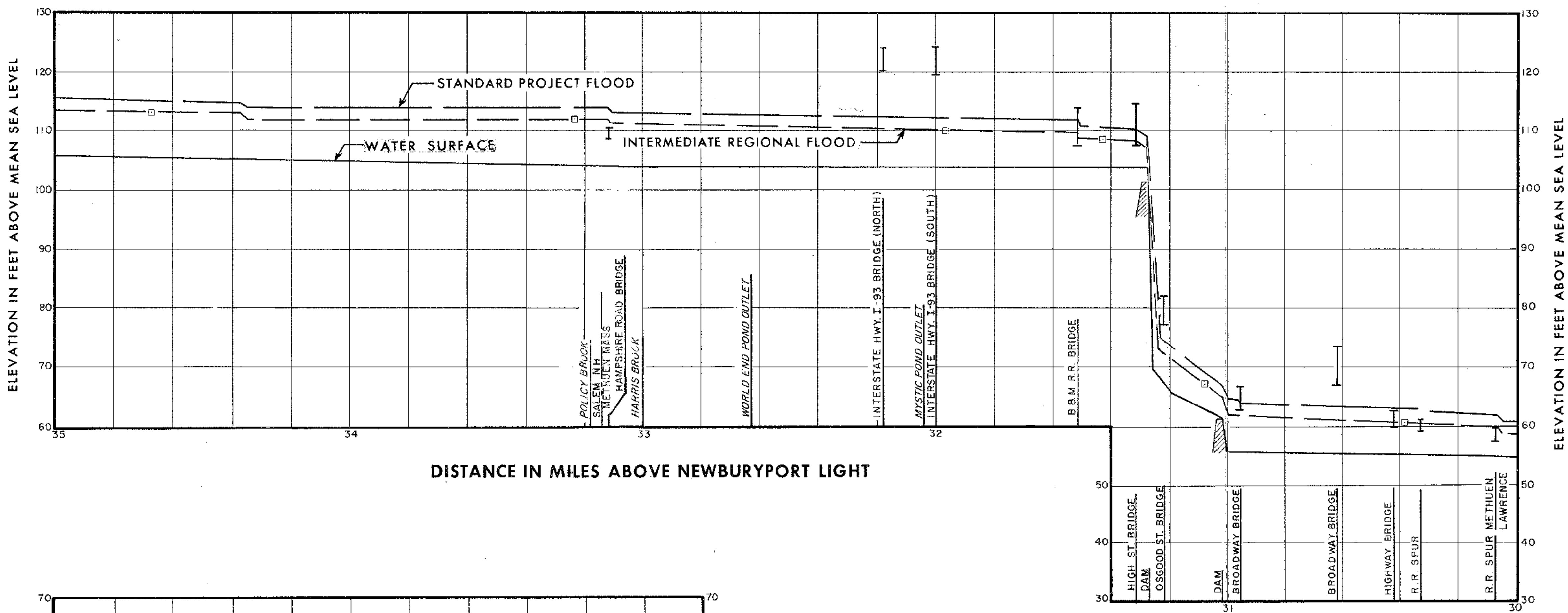
SPICKET RIVER

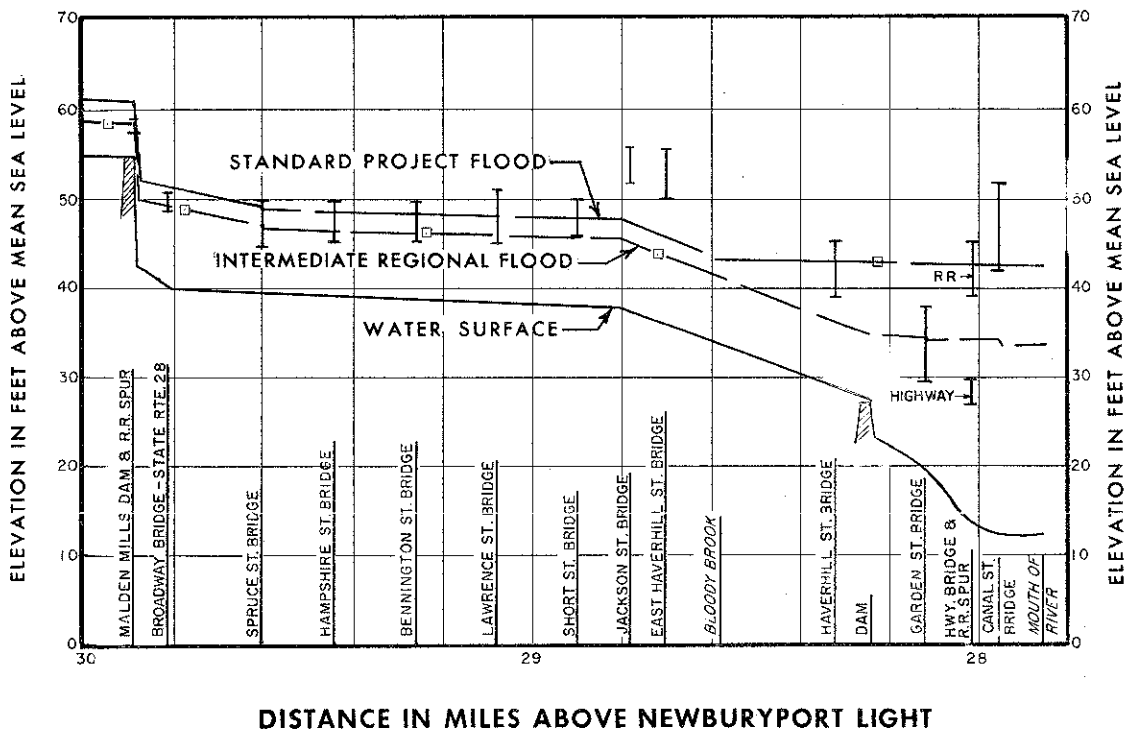
METHUEN
MASSACHUSETTS

PLAN

MARCH 1972 MILE 31.0 TO 33.1

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.





NOTES:

FOR PLANS SEE PLATES NO. SP-1, SP-2 & M-2

LEGEND

- BRIDGE
- DAM
- MARCH 1936 FLOOD HIGH WATER ELEVATION

FLOOD PLAIN INFORMATION

SPICKET RIVER

LAWRENCE - METHUEN, MASSACHUSETTS

FLOOD PROFILES

MARCH 1972

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.